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13. ABSTRACT *(Maximum 200 words)*

The United States Air Force Summer Research Program (USAF-SRP) is designed to introduce university, college, and technical institute faculty members, graduate students, and high school students to Air Force research. This is accomplished by the faculty members (Summer Faculty Research Program, (SFRP)), graduate students (Graduate Student Research Program (GSRP)), and high school students (High School Apprenticeship Program (HSAP)) being selected on a nationally advertised competitive basis during the summer intersession period to perform research at Air Force Research Laboratory (AFRL) Technical Directorates, Air Force Air Logistics Centers (ALC), and other AF Laboratories. This volume consists of a program overview, program management statistics, and the final technical reports from the HSAP participants at the Wright Laboratory.

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UNITED STATES AIR FORCE

SUMMER RESEARCH PROGRAM -- 1997

HIGH SCHOOL APPRENTICESHIP PROGRAM FINAL REPORTS

VOLUME 15B

WRIGHT LABORATORY

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Washington, D.C.

December 1997

PREFACE

Reports in this volume are numbered consecutively beginning with number 1. Each report is paginated with the report number followed by consecutive page numbers, e.g., 1-1, 1-2, 1-3; 2-1, 2-2, 2-3.

Due to its length, Volume 15 is bound in three parts, 15A, 15B and 15C. Volume 15A contains #1-20. Volume 15B contains reports #21-40 and Volume 15C contains reports 41-56. The Table of Contents for Volume 15 is included in all parts.

This document is one of a set of 16 volumes describing the 1997 AFOSR Summer Research Program. The following volumes comprise the set:

VOLUME	TITLE
1	Program Management Report
	Summer Faculty Research Program (SFRP) Reports
2A & 2B	Armstrong Laboratory
3A & 3B	Phillips Laboratory
4A & 4B	Rome Laboratory
5A , 5B & 5C	Wright Laboratory
6	Arnold Engineering Development Center, United States Air Force Academy and Air Logistics Centers
	Graduate Student Research Program (GSRP) Reports
7A & 7B	Armstrong Laboratory
8	Phillips Laboratory
9	Rome Laboratory
10A & 10B	Wright Laboratory
11	Arnold Engineering Development Center, Wilford Hall Medical Center and Air Logistics Centers
	High School Apprenticeship Program (HSAP) Reports
12A & 12B	Armstrong Laboratory
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APPENDICIES:

1. INTRODUCTION

The Summer Research Program (SRP), sponsored by the Air Force Office of Scientific Research (AFOSR), offers paid opportunities for university faculty, graduate students, and high school students to conduct research in U.S. Air Force research laboratories nationwide during the summer.

Introduced by AFOSR in 1978, this innovative program is based on the concept of teaming academic researchers with Air Force scientists in the same disciplines using laboratory facilities and equipment not often available at associates' institutions.

The Summer Faculty Research Program (SFRP) is open annually to approximately 150 faculty members with at least two years of teaching and/or research experience in accredited U.S. colleges, universities, or technical institutions. SFRP associates must be either U.S. citizens or permanent residents.

The Graduate Student Research Program (GSRP) is open annually to approximately 100 graduate students holding a bachelor's or a master's degree; GSRP associates must be U.S. citizens enrolled full time at an accredited institution.

The High School Apprentice Program (HSAP) annually selects about 125 high school students located within a twenty mile commuting distance of participating Air Force laboratories.

AFOSR also offers its research associates an opportunity, under the Summer Research Extension Program (SREP), to continue their AFOSR-sponsored research at their home institutions through the award of research grants. In 1994 the maximum amount of each grant was increased from $20,000 to $25,000, and the number of AFOSR-sponsored grants decreased from 75 to 60. A separate annual report is compiled on the SREP.

The numbers of projected summer research participants in each of the three categories and SREP "grants" are usually increased through direct sponsorship by participating laboratories.

AFOSR's SRP has well served its objectives of building critical links between Air Force research laboratories and the academic community, opening avenues of communications and forging new research relationships between Air Force and academic technical experts in areas of national interest, and strengthening the nation's efforts to sustain careers in science and engineering. The success of the SRP can be gauged from its growth from inception (see Table 1) and from the favorable responses the 1997 participants expressed in end-of-tour SRP evaluations (Appendix B).

AFOSR contracts for administration of the SRP by civilian contractors. The contract was first awarded to Research & Development Laboratories (RDL) in September 1990. After completion of the

1990 contract, RDL (in 1993) won the recompetition for the basic year and four 1-year options.

2. PARTICIPATION IN THE SUMMER RESEARCH PROGRAM

The SRP began with faculty associates in 1979; graduate students were added in 1982 and high school students in 1986. The following table shows the number of associates in the program each year.

YEAR	SRP Participation, by Year			TOTAL
	SFRP	GSRP	HSAP	
1979	70			70
1980	87			87
1981	87			87
1982	91	17		108
1983	101	53		154
1984	152	84		236
1985	154	92		246
1986	158	100	42	300
1987	159	101	73	333
1988	153	107	101	361
1989	168	102	103	373
1990	165	121	132	418
1991	170	142	132	444
1992	185	121	159	464
1993	187	117	136	440
1994	192	117	133	442
1995	190	115	137	442
1996	188	109	138	435
1997	148	98	140	427

Beginning in 1993, due to budget cuts, some of the laboratories weren't able to afford to fund as many associates as in previous years. Since then, the number of funded positions has remained fairly constant at a slightly lower level.

3. RECRUITING AND SELECTION

The SRP is conducted on a nationally advertised and competitive-selection basis. The advertising for faculty and graduate students consisted primarily of the mailing of 8,000 52-page SRP brochures to chairpersons of departments relevant to AFOSR research and to administrators of grants in accredited universities, colleges, and technical institutions. Historically Black Colleges and Universities (HBCUs) and Minority Institutions (MIs) were included. Brochures also went to all participating USAF laboratories, the previous year's participants, and numerous individual requesters (over 1000 annually).

RDL placed advertisements in the following publications: *Black Issues in Higher Education, Winds of Change,* and *IEEE Spectrum.* Because no participants list either *Physics Today* or *Chemical & Engineering News* as being their source of learning about the program for the past several years, advertisements in these magazines were dropped, and the funds were used to cover increases in brochure printing costs.

High school applicants can participate only in laboratories located no more than 20 miles from their residence. Tailored brochures on the HSAP were sent to the head counselors of 180 high schools in the vicinity of participating laboratories, with instructions for publicizing the program in their schools. High school students selected to serve at Wright Laboratory's Armament Directorate (Eglin Air Force Base, Florida) serve eleven weeks as opposed to the eight weeks normally worked by high school students at all other participating laboratories.

Each SFRP or GSRP applicant is given a first, second, and third choice of laboratory. High school students who have more than one laboratory or directorate near their homes are also given first, second, and third choices.

Laboratories make their selections and prioritize their nominees. AFOSR then determines the number to be funded at each laboratory and approves laboratories' selections.

Subsequently, laboratories use their own funds to sponsor additional candidates. Some selectees do not accept the appointment, so alternate candidates are chosen. This multi-step selection procedure results in some candidates being notified of their acceptance after scheduled deadlines. The total applicants and participants for 1997 are shown in this table.

1997 Applicants and Participants			
PARTICIPANT CATEGORY	TOTAL APPLICANTS	SELECTEES	DECLINING SELECTEES
SFRP	490	188	32
(HBCU/MI)	(0)	(0)	(0)
GSRP	202	98	9
(HBCU/MI)	(0)	(0)	(0)
HSAP	433	140	14
TOTAL	1125	426	55

4. SITE VISITS

During June and July of 1997, representatives of both AFOSR/NI and RDL visited each participating laboratory to provide briefings, answer questions, and resolve problems for both laboratory personnel and participants. The objective was to ensure that the SRP would be as constructive as possible for all participants. Both SRP participants and RDL representatives found these visits beneficial. At many of the laboratories, this was the only opportunity for all participants to meet at one time to share their experiences and exchange ideas.

5. HISTORICALLY BLACK COLLEGES AND UNIVERSITIES AND MINORITY INSTITUTIONS (HBCU/MIs)

Before 1993, an RDL program representative visited from seven to ten different HBCU/MIs annually to promote interest in the SRP among the faculty and graduate students. These efforts were marginally effective, yielding a doubling of HBCI/MI applicants. In an effort to achieve AFOSR's goal of 10% of all applicants and selectees being HBCU/MI qualified, the RDL team decided to try other avenues of approach to increase the number of qualified applicants. Through the combined efforts of the AFOSR Program Office at Bolling AFB and RDL, two very active minority groups were found, HACU (Hispanic American Colleges and Universities) and AISES (American Indian Science and Engineering Society). RDL is in communication with representatives of each of these organizations on a monthly basis to keep up with the their activities and special events. Both organizations have widely-distributed magazines/quarterlies in which RDL placed ads.

Since 1994 the number of both SFRP and GSRP HBCU/MI applicants and participants has increased ten-fold, from about two dozen SFRP applicants and a half dozen selectees to over 100 applicants and two dozen selectees, and a half-dozen GSRP applicants and two or three selectees to 18 applicants and 7 or 8 selectees. Since 1993, the SFRP had a two-fold applicant increase and a two-fold selectee increase. Since 1993, the GSRP had a three-fold applicant increase and a three to four-fold increase in selectees.

In addition to RDL's special recruiting efforts, AFOSR attempts each year to obtain additional funding or use leftover funding from cancellations the past year to fund HBCU/MI associates. This year, 5 HBCU/MI SFRPs declined after they were selected (and there was no one qualified to replace them with). The following table records HBCU/MI participation in this program.

SRP HBCU/MI Participation, By Year				
YEAR	SFRP		GSRP	
	Applicants	Participants	Applicants	Participants
1985	76	23	15	11
1986	70	18	20	10
1987	82	32	32	10
1988	53	17	23	14
1989	39	15	13	4
1990	43	14	17	3
1991	42	13	8	5
1992	70	13	9	5
1993	60	13	6	2
1994	90	16	11	6
1995	90	21	20	8
1996	119	27	18	7

6. SRP FUNDING SOURCES

Funding sources for the 1997 SRP were the AFOSR-provided slots for the basic contract and laboratory funds. Funding sources by category for the 1997 SRP selected participants are shown here.

1997 SRP FUNDING CATEGORY	SFRP	GSRP	HSAP
AFOSR Basic Allocation Funds	141	89	123
USAF Laboratory Funds	48	9	17
HBCU/MI By AFOSR (Using Procured Addn'l Funds)	0	0	N/A
TOTAL	9	98	140

SFRP - 188 were selected, but thirty two canceled too late to be replaced.
GSRP - 98 were selected, but nine canceled too late to be replaced.
HSAP - 140 were selected, but fourteen canceled too late to be replaced.

7. COMPENSATION FOR PARTICIPANTS

Compensation for SRP participants, per five-day work week, is shown in this table.

1997 SRP Associate Compensation

PARTICIPANT CATEGORY	1991	1992	1993	1994	1995	1996	1997
Faculty Members	$690	$718	$740	$740	$740	$770	$770
Graduate Student (Master's Degree)	$425	$442	$455	$455	$455	$470	$470
Graduate Student (Bachelor's Degree)	$365	$380	$391	$391	$391	$400	$400
High School Student (First Year)	$200	$200	$200	$200	$200	$200	$200
High School Student (Subsequent Years)	$240	$240	$240	$240	$240	$240	$240

The program also offered associates whose homes were more than 50 miles from the laboratory an expense allowance (seven days per week) of $50/day for faculty and $40/day for graduate students. Transportation to the laboratory at the beginning of their tour and back to their home destinations at the end was also reimbursed for these participants. Of the combined SFRP and GSRP associates, 65 % (194 out of 286) claimed travel reimbursements at an average round-trip cost of $776.

Faculty members were encouraged to visit their laboratories before their summer tour began. All costs of these orientation visits were reimbursed. Forty-three percent (85 out of 188) of faculty associates took orientation trips at an average cost of $388. By contrast, in 1993, 58 % of SFRP associates took

orientation visits at an average cost of $685; that was the highest percentage of associates opting to take an orientation trip since RDL has administered the SRP, and the highest average cost of an orientation trip. These 1993 numbers are included to show the fluctuation which can occur in these numbers for planning purposes.

Program participants submitted biweekly vouchers countersigned by their laboratory research focal point, and RDL issued paychecks so as to arrive in associates' hands two weeks later.

This is the second year of using direct deposit for the SFRP and GSRP associates. The process went much more smoothly with respect to obtaining required information from the associates, only 7% of the associates' information needed clarification in order for direct deposit to properly function as opposed to 10% from last year. The remaining associates received their stipend and expense payments via checks sent in the US mail.

HSAP program participants were considered actual RDL employees, and their respective state and federal income tax and Social Security were withheld from their paychecks. By the nature of their independent research, SFRP and GSRP program participants were considered to be consultants or independent contractors. As such, SFRP and GSRP associates were responsible for their own income taxes, Social Security, and insurance.

8. CONTENTS OF THE 1997 REPORT

The complete set of reports for the 1997 SRP includes this program management report (Volume 1) augmented by fifteen volumes of final research reports by the 1997 associates, as indicated below:

1997 SRP Final Report Volume Assignments

LABORATORY	SFRP	GSRP	HSAP
Armstrong	2	7	12
Phillips	3	8	13
Rome	4	9	14
Wright	5A, 5B	10	15
AEDC, ALCs, WHMC	6	11	16

APPENDIX A -- PROGRAM STATISTICAL SUMMARY

A. Colleges/Universities Represented

Selected SFRP associates represented 169 different colleges, universities, and institutions, GSRP associates represented 95 different colleges, universities, and institutions.

B. States Represented

SFRP -Applicants came from 47 states plus Washington D.C. Selectees represent 44 states.

GSRP - Applicants came from 44 states. Selectees represent 32 states.

HSAP - Applicants came from thirteen states. Selectees represent nine states.

Total Number of Participants	
SFRP	189
GSRP	97
HSAP	140
TOTAL	426

Degrees Represented			
	SFRP	GSRP	TOTAL
Doctoral	184	0	184
Master's	2	41	43
Bachelor's	0	56	56
TOTAL	186	97	298

SFRP Academic Titles	
Assistant Professor	64
Associate Professor	70
Professor	40
Instructor	0
Chairman	1
Visiting Professor	1
Visiting Assoc. Prof.	1
Research Associate	9
TOTAL	186

Source of Learning About the SRP		
Category	Applicants	Selectees
Applied/participated in prior years	28%	34%
Colleague familiar with SRP	19%	16%
Brochure mailed to institution	23%	17%
Contact with Air Force laboratory	17%	23%
IEEE Spectrum	2%	1%
BIIHE	1%	1%
Other source	10%	8%
TOTAL	100%	100%

APPENDIX B -- SRP EVALUATION RESPONSES

1. OVERVIEW

Evaluations were completed and returned to RDL by four groups at the completion of the SRP. The number of respondents in each group is shown below.

Table B-1. Total SRP Evaluations Received

Evaluation Group	Responses
SFRP & GSRPs	275
HSAPs	113
USAF Laboratory Focal Points	84
USAF Laboratory HSAP Mentors	6

All groups indicate unanimous enthusiasm for the SRP experience.

The summarized recommendations for program improvement from both associates and laboratory personnel are listed below:

A. Better preparation on the labs' part prior to associates' arrival (i.e., office space, computer assets, clearly defined scope of work).

B. Faculty Associates suggest higher stipends for SFRP associates.

C. Both HSAP Air Force laboratory mentors and associates would like the summer tour extended from the current 8 weeks to either 10 or 11 weeks; the groups state it takes 4-6 weeks just to get high school students up-to-speed on what's going on at laboratory. (Note: this same argument was used to raise the faculty and graduate student participation time a few years ago.)

2. 1997 USAF LABORATORY FOCAL POINT (LFP) EVALUATION RESPONSES

The summarized results listed below are from the 84 LFP evaluations received.

1. LFP evaluations received and associate preferences:

Table B-2. Air Force LFP Evaluation Responses (By Type)

		How Many Associates Would You Prefer To Get ? (% Response)											
		SFRP				GSRP (w/Univ Professor)				GSRP (w/o Univ Professor)			
Lab	Evals Recv'd	0	1	2	3+	0	1	2	3+	0	1	2	3+
AEDC	0	-	-	-	-	-	-	-	-	-	-	-	-
WHMC	0	-	-	-	-	-	-	-	-	-	-	-	-
AL	7	28	28	28	14	54	14	28	0	86	0	14	0
USAFA	1	0	100	0	0	100	0	0	0	0	100	0	0
PL	25	40	40	16	4	88	12	0	0	84	12	4	0
RL	5	60	40	0	0	80	10	0	0	100	0	0	0
WL	46	30	43	20	6	78	17	4	0	93	4	2	0
Total	84	32%	50%	13%	5%	80%	11%	6%	0%	73%	23%	4%	0%

LFP Evaluation Summary. The summarized responses, by laboratory, are listed on the following page. LFPs were asked to rate the following questions on a scale from 1 (below average) to 5 (above average).

2. LFPs involved in SRP associate application evaluation process:
   a. Time available for evaluation of applications:
   b. Adequacy of applications for selection process:
3. Value of orientation trips:
4. Length of research tour:
5. a. Benefits of associate's work to laboratory:
   b. Benefits of associate's work to Air Force:
6. a. Enhancement of research qualifications for LFP and staff:
   b. Enhancement of research qualifications for SFRP associate:
   c. Enhancement of research qualifications for GSRP associate:
7. a. Enhancement of knowledge for LFP and staff:
   b. Enhancement of knowledge for SFRP associate:
   c. Enhancement of knowledge for GSRP associate:
8. Value of Air Force and university links:
9. Potential for future collaboration:
10. a. Your working relationship with SFRP:
    b. Your working relationship with GSRP:
11. Expenditure of your time worthwhile:

(Continued on next page)

12. Quality of program literature for associate:
13. a. Quality of RDL's communications with you:
    b. Quality of RDL's communications with associates:
14. Overall assessment of SRP:

Table B-3. Laboratory Focal Point Reponses to above questions

	AEDC	*AL*	*USAFA*	*PL*	*RL*	*WHMC*	*WL*
# Evals Recv'd	0	7	1	14	5	0	46
Question #							
2	-	86 %	0 %	88 %	80 %	-	85 %
2a	-	4.3	n/a	3.8	4.0	-	3.6
2b	-	4.0	n/a	3.9	4.5	-	4.1
3	-	4.5	n/a	4.3	4.3	-	3.7
4	-	4.1	4.0	4.1	4.2	-	3.9
5a	-	4.3	5.0	4.3	4.6	-	4.4
5b	-	4.5	n/a	4.2	4.6	-	4.3
6a	-	4.5	5.0	4.0	4.4	-	4.3
6b	-	4.3	n/a	4.1	5.0	-	4.4
6c	-	3.7	5.0	3.5	5.0	-	4.3
7a	-	4.7	5.0	4.0	4.4	-	4.3
7b	-	4.3	n/a	4.2	5.0	-	4.4
7c	-	4.0	5.0	3.9	5.0	-	4.3
8	-	4.6	4.0	4.5	4.6	-	4.3
9	-	4.9	5.0	4.4	4.8	-	4.2
10a	-	5.0	n/a	4.6	4.6	-	4.6
10b	-	4.7	5.0	3.9	5.0	-	4.4
11	-	4.6	5.0	4.4	4.8	-	4.4
12	-	4.0	4.0	4.0	4.2	-	3.8
13a	-	3.2	4.0	3.5	3.8	-	3.4
13b	-	3.4	4.0	3.6	4.5	-	3.6
14	-	4.4	5.0	4.4	4.8	-	4.4

3. 1997 SFRP & GSRP EVALUATION RESPONSES

The summarized results listed below are from the 257 SFRP/GSRP evaluations received.

Associates were asked to rate the following questions on a scale from 1 (below average) to 5 (above average) - by Air Force base results and over-all results of the 1997 evaluations are listed after the questions.

1. The match between the laboratories research and your field:
2. Your working relationship with your LFP:
3. Enhancement of your academic qualifications:
4. Enhancement of your research qualifications:
5. Lab readiness for you: LFP, task, plan:
6. Lab readiness for you: equipment, supplies, facilities:
7. Lab resources:
8. Lab research and administrative support:
9. Adequacy of brochure and associate handbook:
10. RDL communications with you:
11. Overall payment procedures:
12. Overall assessment of the SRP:
13. a. Would you apply again?
    b. Will you continue this or related research?
14. Was length of your tour satisfactory?
15. Percentage of associates who experienced difficulties in finding housing:
16. Where did you stay during your SRP tour?
    a. At Home:
    b. With Friend:
    c. On Local Economy:
    d. Base Quarters:
17. Value of orientation visit:
    a. Essential:
    b. Convenient:
    c. Not Worth Cost:
    d. Not Used:

SFRP and GSRP associate's responses are listed in tabular format on the following page.

Table B-4. 1997 SFRP & GSRP Associate Responses to SRP Evaluation

	Arnold	Brooks	Edwards	Eglin	Griffis	Hanscom	Kelly	Kirtland	Lackland	Robins	Tyndall	WPAFB	average
# res	6	48	6	14	31	19	3	32	1	2	10	85	257
1	4.8	4.4	4.6	4.7	4.4	4.9	4.6	4.6	5.0	5.0	4.0	4.7	4.6
2	5.0	4.6	4.1	4.9	4.7	4.7	5.0	4.7	5.0	5.0	4.6	4.8	4.7
3	4.5	4.4	4.0	4.6	4.3	4.2	4.3	4.4	5.0	5.0	4.5	4.3	4.4
4	4.3	4.5	3.8	4.6	4.4	4.4	4.3	4.6	5.0	4.0	4.4	4.5	4.5
5	4.5	4.3	3.3	4.8	4.4	4.5	4.3	4.2	5.0	5.0	3.9	4.4	4.4
6	4.3	4.3	3.7	4.7	4.4	4.5	4.0	3.8	5.0	5.0	3.8	4.2	4.2
7	4.5	4.4	4.2	4.8	4.5	4.3	4.3	4.1	5.0	5.0	4.3	4.3	4.4
8	4.5	4.6	3.0	4.9	4.4	4.3	4.3	4.5	5.0	5.0	4.7	4.5	4.5
9	4.7	4.5	4.7	4.5	4.3	4.5	4.7	4.3	5.0	5.0	4.1	4.5	4.5
10	4.2	4.4	4.7	4.4	4.1	4.1	4.0	4.2	5.0	4.5	3.6	4.4	4.3
11	3.8	4.1	4.5	4.0	3.9	4.1	4.0	4.0	3.0	4.0	3.7	4.0	4.0
12	5.7	4.7	4.3	4.9	4.5	4.9	4.7	4.6	5.0	4.5	4.6	4.5	4.6
Numbers below are percentages													
13a	83	90	83	93	87	75	100	81	100	100	100	86	87
13b	100	89	83	100	94	98	100	94	100	100	100	94	93
14	83	96	100	90	87	80	100	92	100	100	70	84	88
15	17	6	0	33	20	76	33	25	0	100	20	8	39
16a	-	26	17	9	38	23	33	4	-	-	-	30	
16b	100	33	-	40	-	8	-	-	-	-	36	2	
16c	-	41	83	40	62	69	67	96	100	100	64	68	
16d	-	-	-	-	-	-	-	-	-	-	-	0	
17a	-	33	100	17	50	14	67	39	-	50	40	31	35
17b	-	21	-	17	10	14	-	24	-	50	20	16	16
17c	-	-	-	-	10	7	-	-	-	-	-	2	3
17d	100	46	-	66	30	69	33	37	100	-	40	51	46

4. 1997 USAF LABORATORY HSAP MENTOR EVALUATION RESPONSES

Not enough evaluations received (5 total) from Mentors to do useful summary.

5. 1997 HSAP EVALUATION RESPONSES

The summarized results listed below are from the 113 HSAP evaluations received.

HSAP apprentices were asked to rate the following questions on a scale from 1 (below average) to 5 (above average)

1. Your influence on selection of topic/type of work.
2. Working relationship with mentor, other lab scientists.
3. Enhancement of your academic qualifications.
4. Technically challenging work.
5. Lab readiness for you: mentor, task, work plan, equipment.
6. Influence on your career.
7. Increased interest in math/science.
8. Lab research & administrative support.
9. Adequacy of RDL's Apprentice Handbook and administrative materials.
10. Responsiveness of RDL communications.
11. Overall payment procedures.
12. Overall assessment of SRP value to you.
13. Would you apply again next year? Yes (92 %)
14. Will you pursue future studies related to this research? Yes (68 %)
15. Was Tour length satisfactory? Yes (82 %)

	Arnold	Brooks	Edwards	Eglin	Griffiss	Hanscom	Kirtland	Tyndall	WPAFB	Totals
# resp	5	19	7	15	13	2	7	5	40	113
1	2.8	3.3	3.4	3.5	3.4	4.0	3.2	3.6	3.6	3.4
2	4.4	4.6	4.5	4.8	4.6	4.0	4.4	4.0	4.6	4.6
3	4.0	4.2	4.1	4.3	4.5	5.0	4.3	4.6	4.4	4.4
4	3.6	3.9	4.0	4.5	4.2	5.0	4.6	3.8	4.3	4.2
5	4.4	4.1	3.7	4.5	4.1	3.0	3.9	3.6	3.9	4.0
6	3.2	3.6	3.6	4.1	3.8	5.0	3.3	3.8	3.6	3.7
7	2.8	4.1	4.0	3.9	3.9	5.0	3.6	4.0	4.0	3.9
8	3.8	4.1	4.0	4.3	4.0	4.0	4.3	3.8	4.3	4.2
9	4.4	3.6	4.1	4.1	3.5	4.0	3.9	4.0	3.7	3.8
10	4.0	3.8	4.1	3.7	4.1	4.0	3.9	2.4	3.8	3.8
11	4.2	4.2	3.7	3.9	3.8	3.0	3.7	2.6	3.7	3.8
12	4.0	4.5	4.9	4.6	4.6	5.0	4.6	4.2	4.3	4.5
Numbers below are percentages										
13	60%	95%	100%	100%	85%	100%	100%	100%	90%	92%
14	20%	80%	71%	80%	54%	100%	71%	80%	65%	68%
15	100%	70%	71%	100%	100%	50%	86%	60%	80%	82%

FRICTION AND SOLID LUBRICANTS

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Final Report for:
High School Apprentice Program
Wright Laboratory

Sponsored by:
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and

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FRICTION AND SOLID LUBRICANTS

Erek Kasse
Bellbrook High School

Abstract

The coefficient of friction of various ZnO films and powder composites were studied. To find the coefficient of friction for these films and powders a tribometer was used. The samples were tested at different temperatures, loads, speeds, and humidities. Experimental results indicated only one of the 6 types of films tested exhibited extremely good friction coefficients and very low rates of wear. A variety of ZnO powder composites were also tested and showed fairly good friction coefficients for short periods of time.

FRICTION AND SOLID LUBRICANTS

Erek Kasse

Introduction

Friction is an every day part of life. Without it we would not have brakes, engines, cars, planes, or any other type of machinery. In fact, if we did not have friction we could not perform the simple task of walking because we would just slip, fall, and never be able to get back up. Tribology, or the study of friction and wear, is an ever increasing field in scientific research. Tribologists study the coefficients of friction and wear rates of many solid and liquid lubricants in the never ending task to find the best lubricant with the lowest wear rate. Currently the research of lubricants to be used in outer space operations and jet engine aircraft is the most sought after. Therefore, new lubricants and lubricating techniques are in need of development.

Friction and Wear

Friction is described as the resistance caused by two sliding objects which come into contact with one another. The actual contact of the two solids occurs between the high points on the surface of the solids. The real area of contact is very small and may only be 1/10,000 of the area of the surface. When the load upon the two solids is increased so does the area of contact, which also increases the friction force. Friction itself is expressed by the friction coefficient, which is the ratio of the frictional force to the load. Thus, the friction coefficient is measured by determining the force resisting the sliding of two contacting solids divided by a known constant load. Machines which measure the coefficient of friction are called tribometers, and are used to test many various types of lubricants.

Wear is a very well known and inescapable occurrence: rivers wear away the land around them, wind wears away rocks, knives become dull, and even your shoes wear down. Wear and friction are both related to another being caused by two sliding bodies in contact with one another. Wear is defined as the loss of substance from the surface of a body brought about by mechanical action. There are many forms of

wear including adhesive wear, abrasive and cutting wear, corrosive wear, surface fatigue, and fretting. Adhesive wear occurs every time two metals come in sliding contact. When the two surfaces come into contact, the touching asperities weld together after reaching their melting point and then break apart. Abrasive and cutting wear occurs when the material of one surface is ploughed or gouged out by the surface of a much harder material; it is also sometimes called "scouring". Corrosive wear takes place when a corrosive environment produces a reactive product of one or both of the rubbing surfaces and this reaction product is then removed by the rubbing. Surface fatigue occurs when surfaces are in contact with a rolling motion. This occurs as a result of repeated deformation by either compression, tension, or twisting. As the shaft of a ball or roller bearing rotates, loading and unloading of the track takes place, and for a very long time the material will appear to be unaffected until suddenly a very small piece of the surface will break away. After this, deterioration of the track is very rapid. Fretting is a form of wear when two surfaces at rest with one another are subjected to a slight frictional slip. The initiation of fretting causes any natural protective film to be broken down. Finally, the metal broken away then oxidizes and together with the oxide debris will act as an abrasive.

Lubricants

Lubrication is the reduction of friction or wear between two moving surfaces in contact with one another. The lubrication processes are divided into fluid lubrication and boundary lubrication. Fluid, or hydraulic, lubrication is achieved when the distances between the surfaces is large and they are kept apart by a thick layer of lubricant. Examples of these are oils, greases, WD40, etc. Boundary lubrication is when the distance between the surfaces are kept apart by only a few molecular layers of lubricant not usually more than 50 angstroms thick.

Solid lubricants are materials that will separate two moving surfaces under boundary conditions and decrease the amount of wear. The action of a solid lubricant also depends upon the properties relative to those of the surfaces with which it is in contact. Consequently, a solid lubricant that performs well on one material may generally not perform well on another. The various types of solid lubricants are structural

lubricants, mechanical lubricants, soaps, chemically active lubricants, and development materials. Structural lubricants includes graphite, molybdenum disulphide, mica, talc, and various inorganic salts. In general, lubricants in this class function by cleaving within themselves and fixing themselves on or into bearing surfaces. Mechanical lubricants are capable of forming a continuous adherent film on the rubbing surfaces. This film is then worn away gradually reducing the wear rate until the film has been completely removed. Soaps are used in two ways: first as a solid lubricant by themselves and secondly as compounds formed in the metal surface by the interaction of the fatty acids and the metals. Chemically active lubricants are additives and chemicals which are added to liquids and are able to interact with the metal surface to produce a lubricating layer. Development materials are mostly still classified as they have to do with rocketry and the defense program. However, it has been shown that combinations of various industrial refractory materials are satisfactory for short periods at high temperatures.

ZnO Films

During my stay at Wright Laboratory I tested 6 types of ZnO films. All were of the same chemical make-up but they had different microstructure. Of the 6 types of films I tested, only one was a good solid lubricant with a friction coefficient of .15 in room temperature, under a 200 gm load, and at 200 rpm's. The rest of the samples exhibited friction coefficients of around .7 to 1. In addition to the films that were tested, I also tested a variety of mixtures of powders. These were 1% Sb_2O_3 + 99% Nano ZnO, 10% Sb_2O_3 + 90% Nano ZnO, 50% WS_2 + 50% ZnO, and 50% WS_2 + 50% Nano ZnO. Both mixtures of Antimony Trioxide with Zinc Oxide showed very high friction coefficients of 1 to 1.2. The Tungsten Disulphide and Zinc Oxide mixtures showed friction coefficients of just under .2 for a short period of time which then shot up to about .8 and .9.

Conclusion

I believe that of everything that was tested, the ZnO film that showed the lowest friction coefficient deffinately has potential as a solid lubricant. The rest will not be of any great use because of the extreme conditions they must be able to operate under and still produce a low coefficient of friction.

THE DATABASE DESIGN FOR A CONFIGURATION MANAGEMENT LIBRARY

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Final Report for:
High School Apprentice Program
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THE DATABASE DESIGN FOR A
CONFIGURATION MANAGEMENT LIBRARY

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Abstract

A database was created for an unorganized Configuration Management Library that contained documents, texts, and videos. The database tables were designed, created, and used to update all the information concerning the documents, text, and videos in the Library. The database tables were also designed to contain the descriptions of all the items (documents, texts, and videos) along with all the information needed to locate the items in the library. Forms were also designed for use with the database tables. Forms were created that allowed the user to enter new items into the database. To help physically organize the library, queries were used to sort and group the documents by status; and eventually the queries were used to put all the documents in physical order by document number or title. After the library was organized, reports were created that provided a listing of all the item in the library, along with their physical location. This database for the Configuration Management Library will enable the engineers who use the documents, texts, and videos locate and retrieve the items easily.

THE DATABASE DESIGN FOR A
CONFIGURATION MANAGEMENT LIBRARY

Maria Lee

Introduction

Databases are created to store items of importance and to make finding items easier and faster. Descriptions of items can also be stored in databases, so that there is no need to physically locate an item to find out information about it. Databases have been used to help store and organize any amount of material. They can sort items and put them into a requested order. Indexes can be easily developed from databases to help sort and search items quicker. Any amount of information can be added, deleted, or changed in a database without having to spend a lot of time doing it.

Problem

A Configuration Management Library of documents, texts, and videos was moved from one building to another. During the move, many of the items were misplaced or thrown away. Some new items were even added to the library. After the move, all the items that were added or kept were placed in the new library, but they were not in any particular order or arrangement. The library needed to be organized physically and the government needed someone to design a database for the library documents and organize them.

Methodology

The first step in creating a database from scratch is to do some research on the software application the user will be using—Microsoft Access 7.0. The user does not have to be a master at using the software application, but he must be a little familiar with it. If a problem or question appears later on in the creation process, the books used to do the research will still be available to help solve the problem. The next step is to sketch out the plan on paper instead of designing the table on the computer with no plans or formats in mind. Also, it is wise to know a little about the data that the table is being designed for before planning the table. Basically, sketch out the different types of information the table will contain. For each type of information, there will be a different field that will contain it. A "field" is a single column of a table and in each individual column there will be only one type of data in it. Fields can also be created anytime during the whole database creation process; so if a field needs to be created later on in the process, it

can be done. For this project, the sketch and field design were obtained from old document listings and the author's knowledge of library systems.

After deciding the fields the table will contain at the beginning, the table can then be designed on the computer. This project was to be designed using Microsoft Access 7.0 running under the Windows 95 Operating System. To begin, open Microsoft Access and create a new database. When the database window appears on the screen, push the "Tables" tab; and then push the "New" button. This allows the user to create a new table. When the "New Table" window appears, double click design view. The design view window will appear. This view is used to format the database table, called a datasheet. The design view window will have three columns. The first column, Field Name, will contain each individual field name. The second column, Data Type, is a combo box (a drop-down list box). Choose one of the data types the combo box offers, and that will be the type of information that field will contain. The third column, Description, is the place to type brief descriptions of the fields; so if new data is entered, the person typing the new data can use the description to help him make sure that the data being entered is the correct type for that particular field. The library document table contained many fields at the end of the summer term: Document Number, Technical Number, Title, Document Revision Number, Date, Comments, Status, Responsible Engineer, Organization, Configuration Item Number, # Pages, Estimated, Master, # Masters, Location (M), Label # (M), Working Document, Location (WD), Label # (WD), Copies, # Copies, Location (C), and Subject.

At the bottom of the design view, the "General" and "Lookup" tabs are used to format the data in the table. In the General tab, the Field Size is the maximum number of characters that can be entered in the field. The Format arranges the appearance of the data in the field depending on the code that is used. Input Mask is a pattern that data must match in order to be entered into the field. This helps keep incorrect or data of the wrong format from being entered into the field. The Caption changes the label of the field to a different name form the one used in the Field Name column. The Default Value inserts a default value in the field instead of leaving it blank. The Validation Rule sets up a rule that will only allow certain values to be entered in the field. The Validation Text is the warning given every time the Validation Rule is violated. Required mean there has to be a value in the field before the cursor can go to another record. A record is each individual row or entry in a datasheet. Allow Zero Length means does the field allow zero-length string. If there is no value to be typed into the field, zero-length string allows "" to be typed in place of the value. The "" means there is no value in existence. Indexed means that the field is indexed. Indexes

speed up searches and sorting, but makes updating slower. With the "lookup" tab, it will differ from time to time depending on the data type the field has. Although all these options are available to use, it is not necessary to place requirements on all fields within a table.

For the design of the Configuration Management Table, the following lists of fields were defined. The Document Number (Doc No) field is the number the document is filed under. It has a data type of Text which will allow a mixture of numbers and letters in the field. The Field Size is 30. The Format has a code of > which means all the letters will appear capitalized in the table whether or not the data was typed in upper case or lower case letters. There is no Input Mask, but the Caption is Doc. No.. There is also no Default Value or Validation Rule. This field is not required or indexed, but is does allow zero-length strings. The Display Control on the Lookup tab is text box.

The Technical Number (Tech #) is the technical number of a published document. If the document is a technical report, the report will be filed under the technical number instead of the document number. It has a data type of text. The Field Size is 30, and the Format is >. There is no Input Mask, Caption, Default Value, Validation Rule or Validation Text. The field is not required or indexed, but it does allow zero-length string. The Display Control on the Lookup tab is Text box.

The Title field is the name of the document. It has a data type of Text. The Field Size is 250, and the Format is >.. The field is required and does allow zero-length string, but is not indexed. There is no Input Mask, Caption, Default Value, Validation Rule, or Validation Text. The Display Control on the Lookup tab is Text Box.

The Document Revision Number (Doc Rev #) field is the number of times the document has been revised. The data type is Text. The Field Size is 2, and the Format is >. There is no Input Mask, Caption, Validation Rule, or Validation Text. The Default Value contains =1 which means that unless the value is manually changed in the field, the value in the view will always be 1. The field is not required or indexed. The Display Control on the Lookup tab is Text Box.

The Date field contains the date the document was finished. The data type is Date/Time. The Format is Medium Date which gives the day, month, and then year. For example, the date is 19-Jul-97. There is no Input Mask, Caption, Default Value, Validation Rule, or Validation Text. The field is not required or indexed.

The Comments field are noted about the document the data type is Text. The Field Size 150, and the Format is >. There is no Input Mask, Caption, Default Value, Validation Rule, or Validation Text. The field is not required or indexed, but it does allow zero-length string. The Display Control on the Lookup tab is Text Box.

The Status field contains the status of the document. The data type is Text. The Field Size is 20, and the Format is >. The Validation Rule contains "“APPROVED” Or “HISTORICAL” Or “DUE” Or “IN REVIEW” Or “WORKING DOCUMENT” Or “REFERENCE” OR “DRAFT”.” Everything must be entered exactly as it is between the first and the last quotations but not including them. If the field does not contain one of these values, an error is created. APPROVED means the document is still active. HISTORICAL means the document is historic and no longer in use. Due means that the document is due to be reviewed. IN REVIEW means that the document has not been approved yet. WORKING DOCUMENT and DRAFT means that the document is still being worked upon. REFERENCE means that it is a reference item. The Validation Text contains “Enter one of the values in the drop down list”; so if the value in the field is different from the ones in the Validation Rule, the error box will contain the phrase in the Validation Text. The field is required and allows zero-length string, but it is not indexed. In the Lookup tab, The Display Control is Combo Box which means the field will contain a combo box. The Row Source Type is Value List which means the words in the combo box are the values of the field. The Row Source contains "“APPROVED”;”HISTORICAL”;”DUE”;”IN REVIEW”;”WORKING DOCUMENT”;”REFERENCE”;”DRAFT”.” The values in the Row Source will be the values contained in the combo box. The rest of the values are automatic defaults from the database. For example, the Bound Column and Column Count are both 1. There is no Column Heads, and Column Widths contain nothing. List Rows is 8, List Width is Auto, and Limit To List is No.

The Responsible Engineer (Resp Eng) field contains the name of the engineer that was responsible for the document. The data type is Text. The Field Size is 30, and the Format is >. The Caption is Resp. Eng.. There is no Input Mask, Default Value, Validation Rule, and Validation Text. The field is required, and it allows zero-length string. In the Lookup tab, the Display Control is Text Box.

The Organization (Org) field contains the office symbol of the responsible engineer of the document. The data type is Text. The Field Size is 15, and the Format is >. There is no Input Mask, Caption, Default Value,

Validation Rule, and Validation Text. The field is not required, but it allows zero-length string. In the Lookup tab, the Display Control is Text Box.

The Configuration Item Number (CI #) field the configuration item number of the document. The data type is Text. The field size is 15. The Input Mask is typed in as >LLLA000a;;. Although after it is typed, it will appear as >LLLA000a. The ">", like in Format, is a code that makes all the characters appear in uppercase in the field. Each "L" means that it is a required element, it will only accept letters in that place. The "A" is also a required element, but it will accept letters and numbers in that place. The "0" is a required element, and it will only accept digits in its place. The "a" is a optional code, and it accepts letters and numbers in its place. The ";;" is not required in making the input Mask, but it tells Access 95 to show an underscore where each of the letter will appear. The Caption is CI No.. The field is not required or indexed, but it does allow zero-length string . The Display Control is a Text Box.

The # Pages field contains the amount of pages the document possesses. The Field Size is Integer which allow it to contain numbers from -32,768 to 32,767 . The Format is standard. It has 0 decimal places, and the default value contains =1. There is no Caption, Input Mask, Validation Text, or Validation Rule. The field is not required or indexed. The Display Control is a Text Box.

The Estimated (Est) field shows whether the numbers in the # Pages field are estimated or not. The data type and Format is a Yes/No type. This type will only let certain values be entered into the field. The Caption is Est. The field is not required or indexed. There is no Default Value, Validation Rule, or Validation Text. The Display Control contains a Check Box which means this field is a check box field. If the value in the box should be "yes", check the box by clicking the mouse. If the value is "no", do not check the box.

The Master field shows whether there is a master for the document. The data type is Text, and the Field Size is 4. The Validation Rule contain ""Like "YES" Or "NO"." The Validation Text reads "Type "Yes" if there is a master or "No" if there is no master." The field is required, but it is not indexed. It also does not allow zero-length string. In the Lookup tab, The Display Control is Combo Box. The Row Source contains """YES";"NO"." The rest of the values are automatic defaults from the database. The Bound Column and Column Count are both 1. There is no Column Heads, and Column Widths contain nothing. List Rows is 8, List Width is Auto, and Limit To List is No.

The # Masters field contains the amount of masters and maybe a short note about it. The data type is Text, and the Field Size is 50. The Format is >. The field is not required or indexed, but it allows zero-length string. There is no Caption, Input Mask, Validation Text, or Validation Rule. The Display Control is Text Box.

The Location (M) field shows where the master would be located. The data type is text. The Field Size is 2, and the Format is >. The Validation Rule contains ""Like "F" Or "S" Or "N"." The "F" represents file cabinet. The "S" represents shelf. The "N" represents no location because there is no master. The Validation Text reads "Enter "F" if master located in file cabinet, "S" if master located on shelf, or "N" if there is no location." The field is not required or indexed but it does allow zero-length string. There is no Input Mask, Caption, or Default Value. In the Lookup tab, The Display Control is Combo Box. The Row Source contains ""F";"S";"N"." The rest of the values are automatic defaults from the database. The Bound Column and Column Count are both 1. There is no Column Heads, and Column Widths contain nothing. List Rows is 8, List Width is Auto, and Limit To List is No.

The Label # (M) shows the label # the master is filed under. The data type is Text. The Field Size 25, and the Format is >. The field is not required or indexed, but it allows zero-length string. There is no Caption, Input Mask, Validation Text, or Validation Rule. The Display Control is Text Box.

The Working Document (Work Doc) field shows whether the document is currently being revised. The data type and Format is a Yes/No type. The field is not required or indexed. There is no Default Value, Validation Rule, or Validation Text. The Display Control contains a Check Box.

The Location (WD) field shows where the working document can be located. The data type is Text. The Field Size is 2, and the Format is >. The field is not required or indexed but it does allow zero-length string. There is no Input Mask, Caption, or Default Value, Validation Rule, or Validation Text. In the Lookup tab, The Display Control is Combo Box. The Row Source contains ""F";"S";"N"." The rest of the values are automatic defaults from the database. The Bound Column and Column Count are both 1. There is no Column Heads, and Column Widths contain nothing. List Rows is 8, List Width is Auto, and Limit To List is No.

The Label # (WD) shows the label # the working document is filed under. The data type is Text. The Field Size 25, and the Format is >. The field is not required or indexed, but it allows zero-length string. There is no Caption, Input Mask, Validation Text, or Validation Rule. The Display Control is Text Box.

The Copies field shows whether there are copies for the document. The data type is Text, and the Field Size is 4. The Validation Rule contain ""Like "YES" Or "NO"." The Validation Text reads "Enter "Yes" if copies of document exist, or enter "No" if there are no copies.." The field is required, but it is not indexed. It also does not allow zero-length string. In the Lookup tab, The Display Control is Combo Box. The Row Source contains ""YES";"NO"." The rest of the values are automatic defaults from the database. The Bound Column and Column Count are both 1. There is no Column Heads, and Column Widths contain nothing. List Rows is 8, List Width is auto, and Limit To List is No.

The # Copies field shows the amount of copies for the document. The # Copies field shows the amount of copies the document possesses. The field has a data type of Number. The Field Size is Byte, and the Format is Standard. Byte stores numbers from 0 to 255. Standard allows the numbers to be separated by commas every three digits. It has 0 decimal places. The Validation Rule is >0 Or =0 which means that the number has to be greater than or equal to 0. The Validation text read "Enter number of copies." The field is required, but not indexed. The Display Control is Text Box.

The Location (C) field shows where the copies can be located. The data type is Text. The Field Size is 2, and the Format is >. The Validation Rule contains ""Like "F" Or "S" Or "N"." The Validation Text reads "Enter "F" if copy is located in file cabinet, or enter "S" if copy is located on shelf or "N" if no copies." The field is not required or indexed but it does allow zero-length string. There is no Input Mask, Caption, or Default Value. In the Lookup tab, The Display Control is Combo Box. The Row Source contains ""F";"S";"N"." The rest of the values are automatic defaults from the database. The Bound Column and Column Count are both 1. There is no Column Heads, and Column Widths contain nothing. List Rows is 8, List Width is Auto, and Limit To List is No.

The Label # (C) shows the label # the working document is filed under. The data type is Text. The Field Size 25, and the Format is >. The field is not required or indexed, but it allows zero-length string. There is no Caption, Input Mask, Validation Text, or Validation Rule. The Display Control is Text Box.

The Subject Field shows keywords in the document title. It has a data type of Text. The field size is 250, and the Format is >. It is required and allows zero-length string, but it is not indexed. There is no Caption, Input Mask, Validation Text, or Validation Rule. The Display Control is Text Box.

After formatting all the properties of the table, the data can be entered into the datasheet or--if so desired--on a form. A form is used when the user only wishes to view each individual record separately. Later on, if changes need to be made to the design table, just switch back to the design view of the table.

The Library of Documents has a form designed for it. To design the form, on the database window, push the "Form" tab and then the "New" tab. On the new form window, double click form wizard. On the form wizard window, the Tables/Queries slot should contain Table: library. Also all the available fields should be transferred to the select fields section by clicking the double arrow button. Then push the Next button. On the next window, choose columnar for the layout. The next window after that—the style window, choose stone. Push "Next" again and create a title, Library, for the form. On the same window, click on the modify table dot and then push finish. The design view of the form should open. Any modification or adjustments can be made here. Such changes as size or location of each field. All the form fields, should have the same properties as the datasheet fields because the form was linked with the Library of Documents table. To start entering data onto the forms, go to the form view. All data entered on the form will correspond with the data on the datasheet and vice versa.

After organizing the database on the computer, the library needed to be physically organized. Queries were used in this aspect of organizing the Library. Two queries were created to sort between all the masters and all the copies. To make a query, on the database window push the "Queries" tab and the "New" tab. On the new query window, double click design view. On the show table window, add the Library table and then close. On the query design table, drag the Doc. No., Title, and Master fields to Field row at the bottom of the window. In the Sort row beneath the Doc. No. and Title, choose Accending. This will put the records in order by Doc. No. and then Title. In the Criteria row beneath Master type "YES". This will sort all the documents that are masters. The reason this query was created was due to the fact that all master documents had to be placed in the file cabinets. Other queries were created so that the masters could be separated by status and then put in order by document Number. This was done by adding the Status field to the given design view. A separate query was created for each type of status. When designing the queries, in the Criteria row beneath the Status field put the different statuses with quotes around them. The ones that do not have document numbers are placed before the ones that do have document numbers. A query also helped put the APPROVED (active) copies on the shelf by sorting them and then placing them in order by document number on the shelves. Another query was created that contained Doc. No., Title, and Copies. In the

Criteria row under copies, type YES with quotes around it. This will sort all the documents that have copies. Put the copies on the shelves. After all the documents were place in the right place, labels for the shelves, cabinets, and file folders were made.

After all the data was entered, a report was ready to be made. Two Library Document Indexes were made from the Library table. The Indexes contained only the status, document number, title, and date of the documents. To make the first index, on the database window, push the "Report" tab and then the "New" tab. On the New Report window, double click the Report Wizard. The Tables/Queries slot should contain Table: library. Select the four fields in the order that it will appear on the report by highlighting each one and then push the single arrow button. Skip the grouping level screen by pushing Next without making any changes. The next window is the sort order window. Put the fields in this order: status, document number, title, and date. Sort status, document number, and then title by alphabetical order. This will group the statuses together first. Then put the document number in alphabetical order, and if there is no document number, it will group all the ones without document numbers by title. They will be placed at the beginning of each of the status group in alphabetical order. If any adjustments or modifications need to be made, it can be done on the report design view. To make the second index, follow the same steps as the first one, except put title before the document number on the sort order window.

Although the Library is mostly documents, there are a few texts and videos. Two separate tables were made for them in the same database as the documents. The Text table possessed fields of Title, Author, Subject, Edition, Year, Publisher, Editor, ISBN #, Congressional #, Card #, Pages, Copies, and location. The Video table possessed fields of Title, Time, Company, Year, Copies, Subject, and Location. Both texts and videos were physically placed on shelves. Not only the tables are made, but reports were also created for them. These tables and reports were made in the same way as the documents table and report.

<u>Results</u>

After creating the database, all the forms and physically organizing the Configuration Management Library, the result is a very effective and organized way of finding some document, text, or video. Masters are separated from the copies. There is even a separation between master by status. The information concerning the new library has been updated in the process of creating the database. Because of the update, new indexes could be made from the

reports. All this work will be used by the engineers in Wright Laboratory to find and retrieve documents easily from the library.

Conclusion

A unorganized Configuration Management Library should be organized and have a database, so that people do not have to spend a lot of time looking for a piece of information. The new library database can assist the engineers by helping them locate a document pretty easily. Also, with a computer database every time new data is added or taken away, the information can be easily added or deleted without making a mess of the system.

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THE EFFECT OF CHAIN LENGTHS ON BOND ORDERS AND GEOMETRY IN SIMPLE CYANINES

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Final Report for:
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THE EFFECT OF CHAIN LENGTHS ON BOND ORDERS AND GEOMETRY IN SIMPLE CYANINES

Colleen LeFevre

Abstract

The main objective of this experiment is to observe the trends in various characteristics of the simple cyanines as the number of carbons is varied. Models were first made of the simple cyanines in Chem 3D, then the geometries were optimized using molecular mechanics. Finally, self consistent field (SCF) semi-emperical calculations were performed using MOPAC93. The data was organized and analyzed on spreadsheets.

Different calculations were then performed (CI and Hartree-Fock *ab initio*) in order to test the validity of the MOPAC calculations. Experimental data was also used for comparison. The calculations were in sufficient agreement to predict trends in the cyanine molecules.

It was observed that as more carbon atoms are added to the cyanine chain, the geometry becomes asymmetric and less stable, and the bond orders tend to localize in the larger chains.

THE EFFECT OF CHAIN LENGTHS ON BOND ORDERS AND GEOMETRY IN SIMPLE CYANINES

Colleen LeFevre

Background/Introduction

Laser light can be very harmful to the human eye and to sensitive equipment. With the increasing use of lasers, the chances for laser-related injuries is increasing. Much emphasis is being placed on laser protection. The purpose of the Laser Hardening Project is to develop a material that will arrive at the excited state almost instantly when hit with laser light so the transmission decreases and the absorption increases, keeping the laser light blocked. This material then will be used in goggles and other safety devices for laser protection.

Those working on the Laser Hardening project are divided into five main groups: Computational, Synthesis, Optical Characterization, Process and Morphology, and Optical Design. The Computational Group works on modeling molecules that are made by the Synthesis Group. It looks for the lowest energy form for the molecules. It attempts to explain what is happening to the experimental data by changing the parameters of the molecule to fit the computational data to the experimental data. If the data fits, the Computational Group can explain what is happening to the laser light as it is passed through the material.

The Synthesis Group researches literature, then synthesizes molecules. After the molecule is made, it is purified and characterized in order to confirm the molecule type. This group also prepares samples for laser testing. It makes a spectral analysis to give to

the Optical Characterization Group.

The Optical Characterization Group tests the samples in various laser geometries. The wavelengths, focal geometry for optics, and pulse widths all serve as variables in the testing. The different laser set-ups help to define the interaction for the mechanism that most affects the laser light in the sample. The results of the laser testing are then sent back to the Synthesis group, where they are studied and used to make better molecules.

The Process and Morphology Group works with solid samples. It determines the best methods to make the liquid sample into a solid sample (films, gels, etc.) so it can be better used in actual products (such as safety goggles). It sends the sample to laser testing, then uses that data to work on making a better sample. The surface is looked at under SEM's (Scanning Electron Microscopes) and AFM's (Atomic Force Microscopes). The goal of the group is to make the sample as smooth and as flat as possible. The Optical Design Group focuses on how the tested material can be used in specific situations. It sets the requirements for all the other groups to meet. It also tries to re-design the optical system to fit the sample. The system must be very compact in order to use it in real life. This paper will focus on the computational work in the Laser Hardening project.

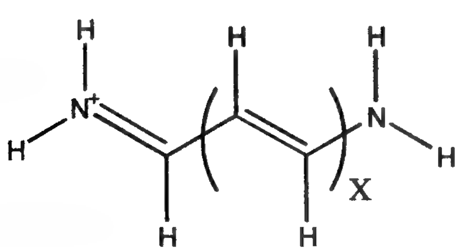
The goal of the Computational Group is to understand the functions of each part of a molecule. The Computational Group finds the structures that are responsible for various characteristics of molecules. Synthesis takes a long time. There are several variations of molecules that need to be tested. The Computational Group attempts to eliminate the time-consuming trial and error in the synthesis process by predicting the best molecules. It looks at the calculations for molecules, and compares that data to the data

collected from the actual synthesized molecules. Then, trends are observed and after knowing all the details of a molecule and the function of each structure, it can then save time by predicting specific molecules that will have the best performance.

This project deals with the simple cyanines and their structures. The data gathered from computer MOPAC calculations were analyzed and compared to actual molecule data and also other MOPAC calculation types for verification.

Discussion of Problem

Substances known as the cyanine dyes (or polymethines) are being studied in order to find their uses in optical limiting. The goal of these studies is to be able to eventually control the absorption minimums and maximums and their locations, and also control the width of the absorption maximum and transmission window. Much is already known about the linear absorption of the simple cyanines (Figure 1), but not much is known about the non-linear/excited states of the simple cyanines and their property relations. In order to learn about the excited states of the simple cyanines, it is necessary to first learn about the exact geometry of the molecules, then to learn about the ground state of the molecules. This experiment will take the first step to understanding the simple cyanines-- it will examine the geometry of the simple cyanines as the length of the carbon chain is increased.



X= 0-8

Figure 1. Simple Cyanines

There are two main reasons for looking at the simple cyanines for optical limiting. First, the basic cyanine chromophore is found to be one of the most important chromophores for RSA (reverse saturable absorption). RSA means that the material will react to intense light- e.g. laser light, and become more absorbing. The second reason for studying the simple cyanines is that there is a need to make NIR (near infra red-- 700nm-1500nm) and RSA chromophores. It is known that by increasing the length of the carbon chain, the absorption increases to longer wavelengths and is in the range of the NIR. Simple cyanines are small molecules, so it is possible to go to higher levels of calculations than in some of the more complex molecules. This allows us to achieve a better understanding of the molecules-- it helps to isolate the mechanism that gives the molecule specific properties.

Past studies have shown that upon adding carbons to the chain in cyanines, the molecule becomes asymmetric and less stable. Bond order alternation is apparent, and there is a shift in the absorption. The absorptivity shifts to longer wavelengths as the number of carbons is increased and the absorption gets more intense at first, then the peaks get less exaggerated and a lot smaller.[1, 7]

The purpose of this experiment is to understand how the basic optical properties vary when the number of carbons in a chain is increased and substituent additions are made on the cyanine chromophores. The structure-property relationships will be examined.

Methodology

This experiment consisted of a series of computer operations and calculations. First, cyanine models were constructed on a computer using the program Chem Draw.[2] These models were then transferred to another program, Chem 3-D.[3] In this program, the models were "cleaned up" using the molecular mechanics minimizer (MM2). Next, the models were transferred to Cerius2.[6] Here, the molecules were adjusted in order to achieve a symmetric and well-defined starting geometry. The geometry of the molecules were then optimized with MOPAC93 using PM3 Hamiltonian.[5]

The data collected from the MOPAC93 calculations were organized on a spreadsheet and analyzed. Then, configuration interaction (CI) calculations were performed on the molecules in order to test the validity of the geometry for the molecules. Hartree-Fock *ab initio* calculations,* CI calculations, and experimental data were used. The geometry data for each calculation was placed on a spreadsheet for comparison. (If there was agreement between the different geometry calculations, trends could then be predicted in calculation results.)

Results

Before any trends could be observed, it was necessary to validate the accuracy of the molecule geometry. As part of this validification process, different types of MOPAC calculations were compared. The Hartree-Fock (HF) *ab initio* calculations were assumed to give the most accurate molecule geometries and the other semi-emperical MOPAC

calculations were compared to it. In comparing the HF calculations to the SCF calculations, the calculations were very similar in the bond lengths, but not as close in the bond angles.

The trends in the HF calculations can be seen clearly in the PM3 SCF calculations. (see Table 1)

Table 1. HF, PM3 SCF, PM3 CI calculations

			Hartree-Fock *ab initio* Calculations		
	CI Level	N-C1	C1-C2	C2-C3	mba
		Å	Å	Å	deg.
Ncn		1.303			125.16
n3cn		1.312	1.388		118.57
n5cn		1.318	1.384	1.393	125.44
			PM3 SCF Calculations		
ncn		1.349			122.62
n3cn		1.339	1.397		120.22
n5cn		1.343	1.395	1.392	122.03
			PM3 CI Calculations		
ncn	2cisd	1.350			123.34
ncn	2cis	1.387			122.22
ncn	4cisd	1.352			123.17
ncn	4cis	1.387			122.22
ncn	6cisd	1.352			123.15
ncn	6cis	1.387			122.23
n3cn	2cisd	1.341	1.396		120.20
n3cn	2cis	1.345	1.421		118.66
n3cn	4cisd	1.343	1.396		120.19
n3cn	4cis	1.359	1.414		119.16
n3cn	6cisd	1.351	1.405		118.03
n3cn	6cis	1.362	1.410		119.24

In the first Nitrogen-Carbon bond (N-C1), going down the column, the bond length gets larger as the number of carbons is increased. In the first Carbon-carbon bond (C1-C2), the bond length gets shorter as the number of carbons is increased. Despite the differences in the actual values for the meso bond angle (mba), the same pattern occurs for both calculations. As the number of carbons is increasing, the angle first gets small, then large again.

In comparing the PM3 CI calculations to the HF calculations, it was observed that the CI singles and doubles (CISD) calculations for the bond lengths came closest to the HF calculations. It was also found that the CISD level 6 was the best.

The calculated data was also compared to some experimental data.[4] Figure 2 shows a linear relationship between the calculated HOMO-LUMO (HL) gap and the experimental HL gap.

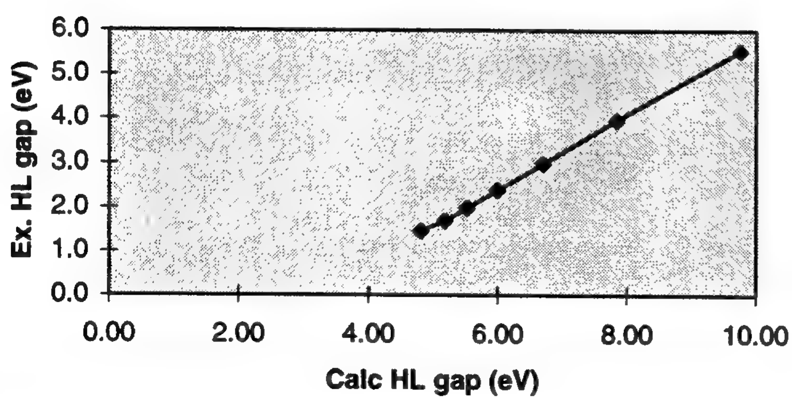


Figure 2. Calculated HL gap vs. Experimental HL gap

Overall, it was concluded that the agreement in the calculations and experimental data is

reasonable and sufficient to predict trends in the calculation results.

One of the trends observed was in the geometry. Figure 3 are the MOPC optimized geometries as seen in the plane of the carbon backbone and illustrates the change in geometry for the simple cyanines as the number of carbons is increased.

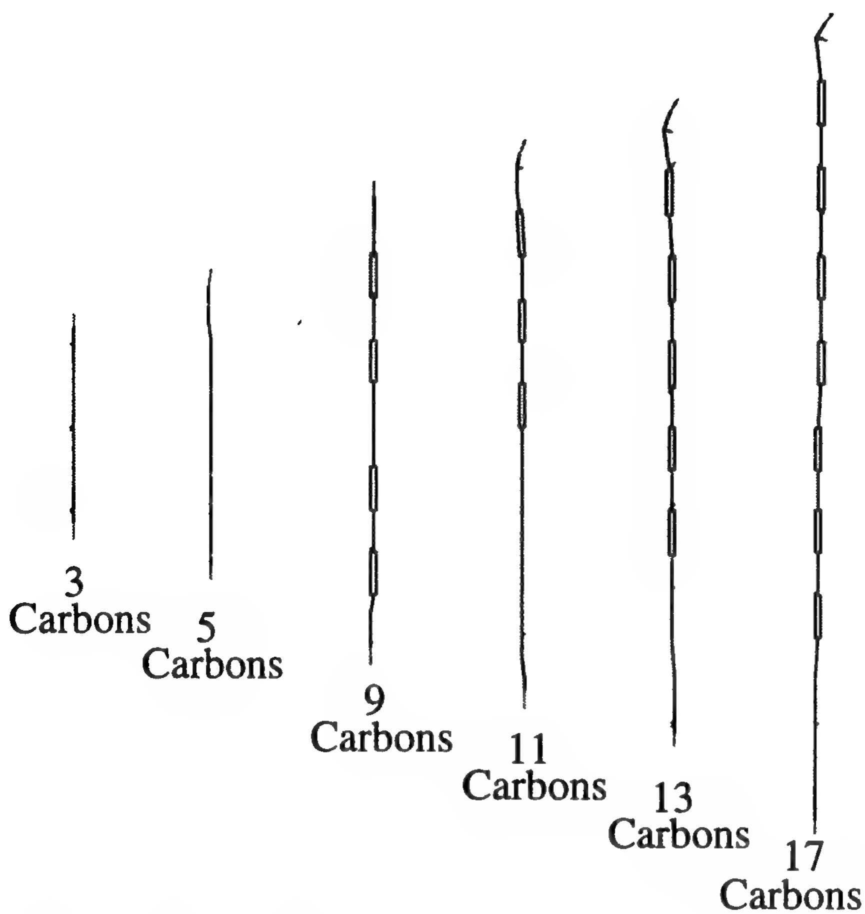


Figure 3. Wire frame models showing geometry variations with the increase of carbon atoms to a chain.

As seen above, the molecules with 9 carbons or less were symmetric and planar, and the molecules with 11 carbons or more were asymmetric and non-planar, with the amine group twisted out of planarity. As seen in Table 2, the point groups also demonstrated this "twisting" of the geometry.

The strongest absorption maxima are the $\pi \rightarrow \pi^*$ transitions observed in conjugated planar molecules.[8] The increase in the "twisting" out of planarity in the geometry as the number of carbons is increased indicates that the absorption intensity will decrease. It is hypothesized that upon the excitation of molecules into delocalized LUMO states, the molecules will become planar, and an increase in the absorption intensity will result in the conjugated structure.

Table 2. This table shows the point groups for each molecules with the specified number of carbons in the chain.

#C	Point Gr.
1	C2v
3	C2v
5	C2v
7	C2v
9	C2v
11	C2
13	C2
15	C2
17	C1

In the cyanines with 9 or less carbons, the point group was C2v. In cyanines with 11-15 carbons, it was C2. In the cyanine with 17 carbons, the group was C1.

Figure 4 is a plot of the bond orders of the carbons in cyanines with reference to their positions. The meso carbon is at position 0.

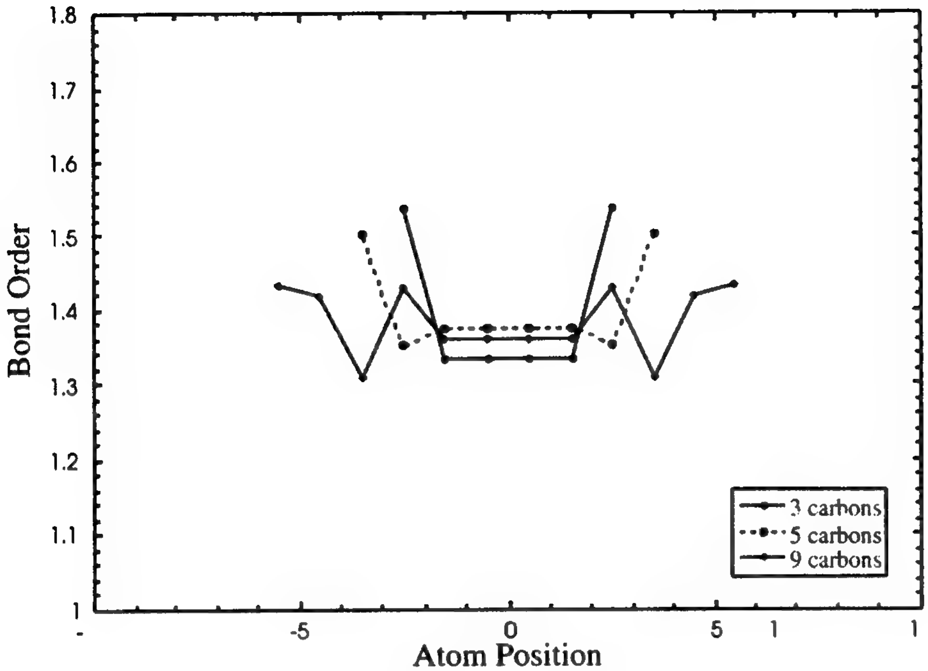


Figure 4. Bond Order vs. Atom Position

The bond orders in the central region of the molecules are uniform-- all around 1.4, indicating significant charge delocalization. As the carbon chain gets larger, some bond alternation is seen near the ends, giving the first indication of charge localization.

Figure 5 illustrates the variations between the bond orders of the carbons in the larger cyanine molecules. As in Figure 4, the meso position carbon is positioned at the 0 point on the plot.

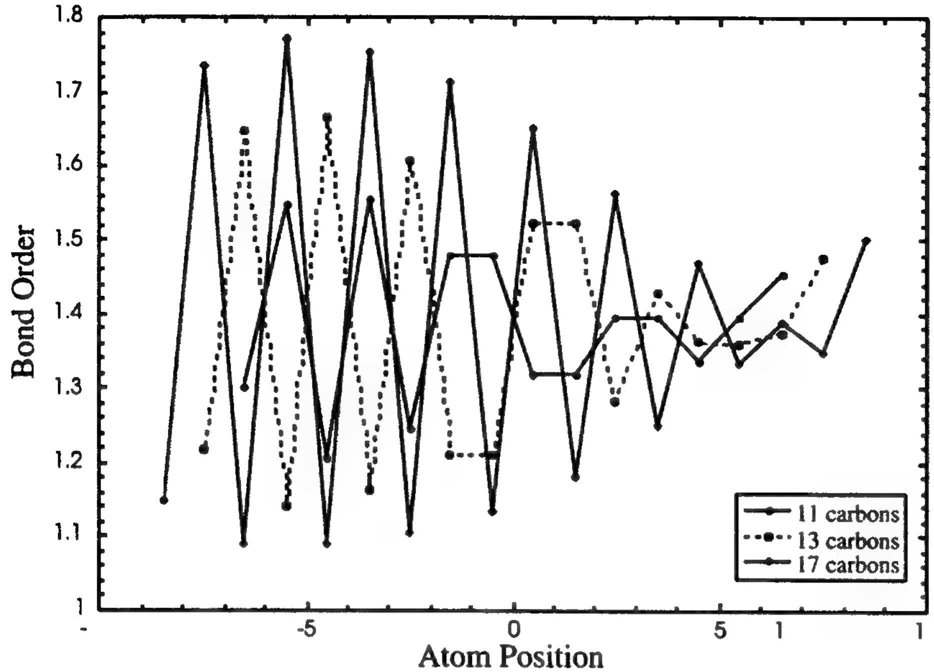


Figure 5. Bond Order vs. Atom Position

This plot (Figure 5) demonstrates that in the larger size molecules, the electrons are localized and alternating bond orders are apparent. The molecules become asymmetric. This observation was strengthened by the plot of the dipole moment vs. the

length of the carbon chain (Figure 6)

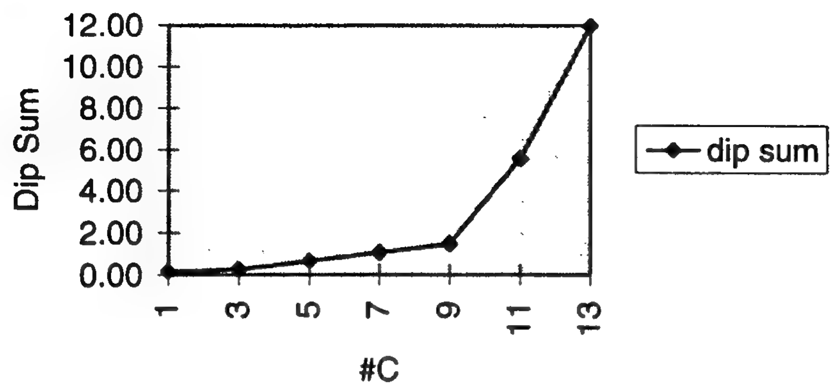


Figure 6. Dipole Sum total vs. #Carbons

This plot shows a clear increase in the dipole moment as the number of carbons is increased to 11. The sudden increase in the dipole moment helps to verify the observed electron localization.

Conclusion

In this experiment, conclusions were based on the trends in the calculations of the molecules, and on the past studies done on the topic. First, it was concluded that the geometry changes (due to chain length) of the simple cyanines can be reproduced by different calculation types and levels (PM3 CI level and PM3 SCF). The calculations do not, however, provide reliable absolute geometries for the molecules.

It was also concluded that when lengthening the carbon chain length in the cyanine molecules, the geometry begins to collapse. Also apparent as the length of the chain

increases, is a localization of the electrons, i.e. the bond orders tend to alternate in the larger cyanine molecules. This collapse in the geometry prevents the HOMO-LUMO energy gap from decreasing to zero with the addition of carbon atoms to the chain, and thus this limits the ability to shift the absorption to longer wavelengths.

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A STUDY OF TWO METHODS FOR PREDICTING FIN CENTER OF PRESSURE POSITION

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Final Report for:
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Wright Laboratory

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Abstract

Two computer based methods for predicting the location of the center of pressure of a missile fin were studied. One was a function of fin geometry and normal force coefficient, the other was a function of fin geometry only. They were compared with data obtained on seven different fins that were tested on a body and six fins that were tested on a splitter plate. The method that was a function of fin geometry and normal force gave good or fair agreement for all 13 cases studied. The method that was a function of fin geometry gave poor agreement for eight of the 13 cases studied and good agreement for only 3 cases.

Nomenclature

C_N	Coefficient of Normal Force
C_R	Root Chord
AR	Aspect Ratio
TR	Taper Ratio
M	Mach Number
XCP	Center of Pressure
Λ	Sweep Angle

Introduction

One feature common to all stealth aircraft that have been developed is that all weapons (bombs, missiles) are carried internally. This prevents the weapons from affecting the aircraft radar signature. The volume required for internal weapons carriage increases weight and drag and decreases range by using space that could otherwise have been used for additional fuel. Hence, minimizing the size of the weapons to be carried internally is paramount. The maximum span of missile fins has a major impact on the required volume for internal carriage. One factor that contributes to this span is the size of the actuators required for controlling the fin deflection. The actuators are sized by the hinge moment that is required to be generated. This is determined by the product of the load on the fin and the axial distance between where the load acts and the fin hinge line. The load acts at the fin "center of pressure". This is a function of many parameters, including fin shape, deflection, load and Mach number. Accurate methods are needed for computing fin center of pressure to properly design the fin and select the hinge line location.

Several methods are available for predicting missile aerodynamics. One method, developed and distributed by the USAF Wright Laboratory, is a computer code called Missile Datcom (Ref. 1). Over 200 organizations used Missile Datcom. At the 1997 AIAA Applied Aerodynamics Conference, two papers were presented that criticized the capability of Missile Datcom to accurately predict missile fin hinge moments (Refs. 2,3). The objective of this study was to compare the method used in Missile Datcom to a method developed by Nielsen Engineering and Research (NEAR, Ref. 4), and to compare both to experimental data (Refs 5,6).

Methodology

The location of a fin's center of pressure is dependent on a number of variables associated with the fin. It is still uncertain as to how these variables affect the center of pressure, however. Both Missile Datcom and NEAR have methods for predicting a fin's center of pressure, but they require different data inputs connected with the fin. This study looks at evaluating the variables that were chosen by each of the prediction methods.

Separate wind tunnel tests from the early 1970's and from May 1997 produced data that included figures for the centers of pressure of several different fins. Of these fins, seven were chosen to be used as the testing population for comparing prediction methods. Data from each fin on a splitter plate as well as that fin attached to a body were entered into the computer. Then, with a program that uses the NEAR prediction method, values were calculated for the same fin's center of pressure at certain values of C_N. Also, a single value for that fin's center of pressure was calculated using the Datcom method, since Datcom assumes XCP is independent of C_N.

For each of the seven fins, a graph was created which plotted the values taken from the wind tunnel tests along with the predictions made by both NEAR and Datcom. Then the graphs were evaluated as to how close the predictions came to the experimental data.

Missile Datcom method

.The Missile Datcom method for predicting center of pressure is based on a large experimental data base obtained in Sweden in 1954. This database was used to generate a set of charts. These charts were converted to data tables which were put into Missile Datcom. These data tables are a function of four variables: AR, TR, M, and Λ.

NEAR method

The NEAR method for predicting center of pressure is based on a large experimental data base obtained at NASA from 1981 to 1989. NEAR took this data and created tables that were a function of four variables: AR, TR, M, and C_N. They wrote an interactive computer program that requires the user to input these four variables and provides as output the center of pressure. Linear interpolation is used for cases where the input variables differ from what was tested at NASA.

The Missile Datcom and NEAR methods are compared in Figure 1. This figure shows the variation in center of pressure with M for three fin planforms. The methods are in general agreement with one another, although the Missile Datcom method shows much less variation with M compared with the NEAR method.

Results

Figure 2 shows the fin geometries used in this study from Ref. 5 The results for these fins are shown in figures 3-6 and are summarized in Table 1 and 2. Figure 7 shows the fin geometries used on this study from Ref. 6. The results for these fins are shown in figures 8-10 and are also summarized in Table 1 and 2. Figure 3-6 and 8-10 show

the fin center of pressure as a function of the fin normal force coefficient. At low values of fin normal force, the fin hinge moment is also small, so numerical problems can arise from dividing one small number by another. This is seen in the figures as increased scatter near zero fin normal force.

Good agreement is defined as the predicted center of pressure being within 5% chord of the experimental value for virtually all values of fin normal force. Fair agreement is defined as the predicted center of pressure being within 5% chord over 40% of fin normal force. If the predicted center of pressure was in error by more than 5% chord for the majority of fin normal forces, the agreement is considered poor.

TABLE 1 COMPARISON OF PREDICTED CENTER OF PRESSURE WITH EXPERIMENTAL VALUES OBTAINED WITH THE FIN MOUNTED ON A SPLITTER PLATE

Fig	Fin	Test	M	AR	TR	sweep	t/c (TE)	NEAR	MISDAT
3	11	AEDC	0.8	1	1	0.00	0	fair	poor
4	14	AEDC	0.8	1	0	75.95	0	fair	good
6	36	AEDC	0.8	0.5	0	82.87	0	fair	good
8	A	SARL	0.35	2	1	0	0	good	poor
9	B	SARL	0.35	2	1	0	0.0875	fair	poor
10	C	SARL	0.35	2	1	0	0.175	fair	fair

TABLE 2 COMPARISON OF PREDICTED CENTER OF PRESSURE WITH EXPERIMENTAL VALUES OBTAINED WITH THE FIN MOUNTED ON A BODY

Fig	Fin	Test	M	AR	TR	sweep	t/c (TE)	NEAR	MISDAT
3	11	AEDC	0.8	1	1	0.00	0	good	poor
4	14	AEDC	0.8	1	0	75.95	0	fair	poor
5	15	AEDC	0.6	1	0.5	53.10	0	good	poor
6	36	AEDC	0.8	0.5	0	82.87	0	good	good
8	A	SARL	0.35	2	1	0	0	good	poor
9	B	SARL	0.35	2	1	0	0.0875	fair	poor
10	C	SARL	0.35	2	1	0	0.175	fair	fair

The experimental data shows that the fin center of pressure when mounted on a splitter plate is usually very close to the value when mounted on a body. The data also show that the center of pressure moves aft on the fin as the fin normal force increases. The NEAR method is able to predict this trend while the Missile Datcom method is not. The NEAR method shows good agreement for 5 of the 13 cases studied. The Missile Datcom method shows good agreement for only 3 of the 13 cases studied. The NEAR method shows poor agreement for none of the 13 cases studied. The Missile Datcom method shows poor agreement for 8 of the 13 cases studied.

Conclusion

A method developed by NEAR Inc for predicting the location of the center of pressure of a missile fin was compared to the method currently in the Missile Datcom computer code. The purpose was to determine whether the Missile Datcom method should be replaced with the NEAR method. The NEAR method is a function of fin geometry and normal force coefficient, while the Missile Datcom method is a function of fin geometry only. They were compared with data obtained on seven different fins that were tested on a body and six fins that were tested on a splitter plate. The NEAR method gave good or fair agreement for all 13 cases studied, while the current Missile Datcom method gave poor agreement for eight of the 13 cases studied and good agreement for only three cases. It is recommended that the NEAR method be incorporated into future versions of the Missile Datcom code.

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6 Unpublished data from May 1997 SARL wind tunnel test.

FIGURE 1

Fin Center of Pressure Comparison, Datcom vs NEAR Predictions

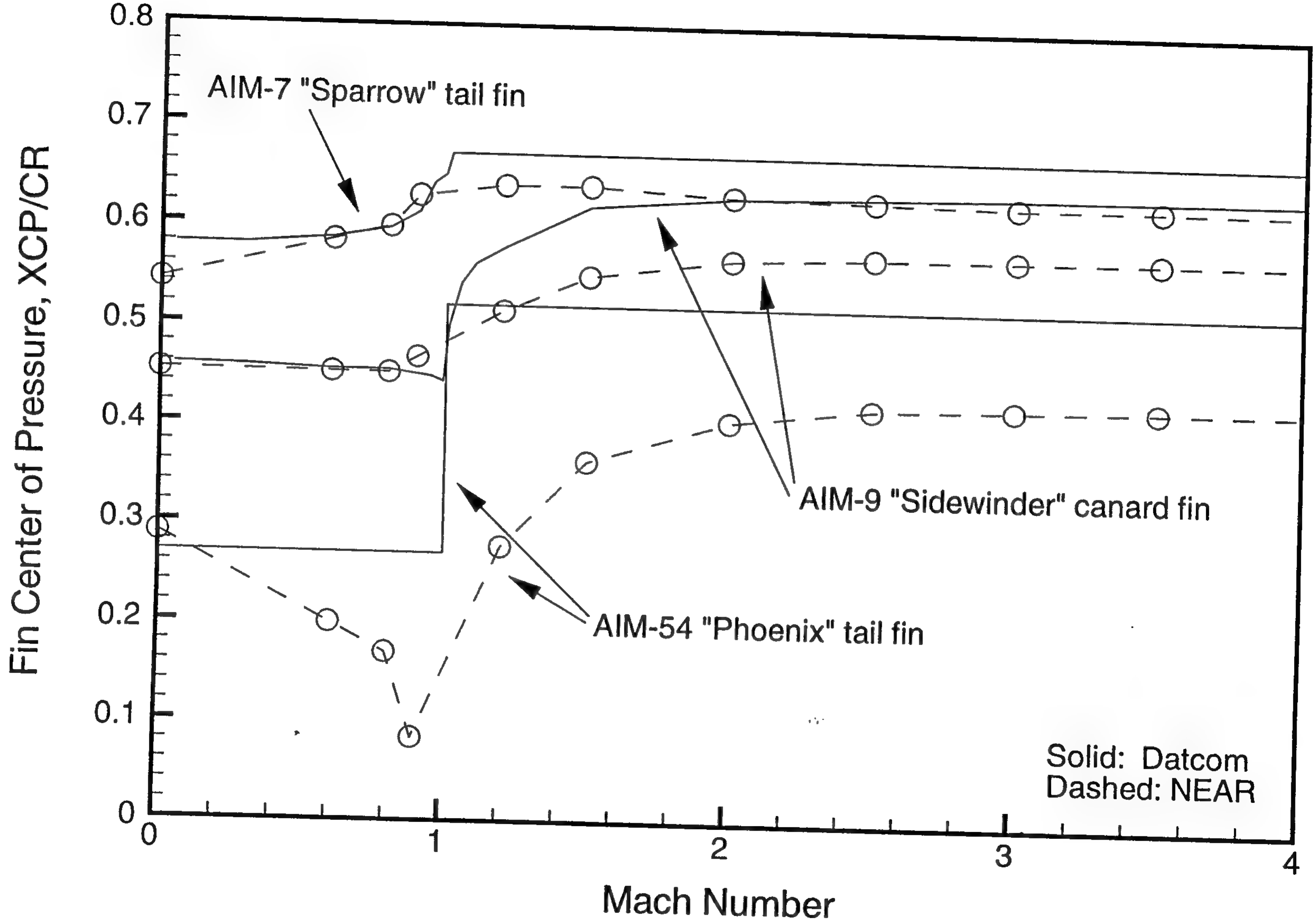


FIGURE 2

MISSILE FINS TESTED AT AEDC, March 1976

Report AEDC-TR-75-125

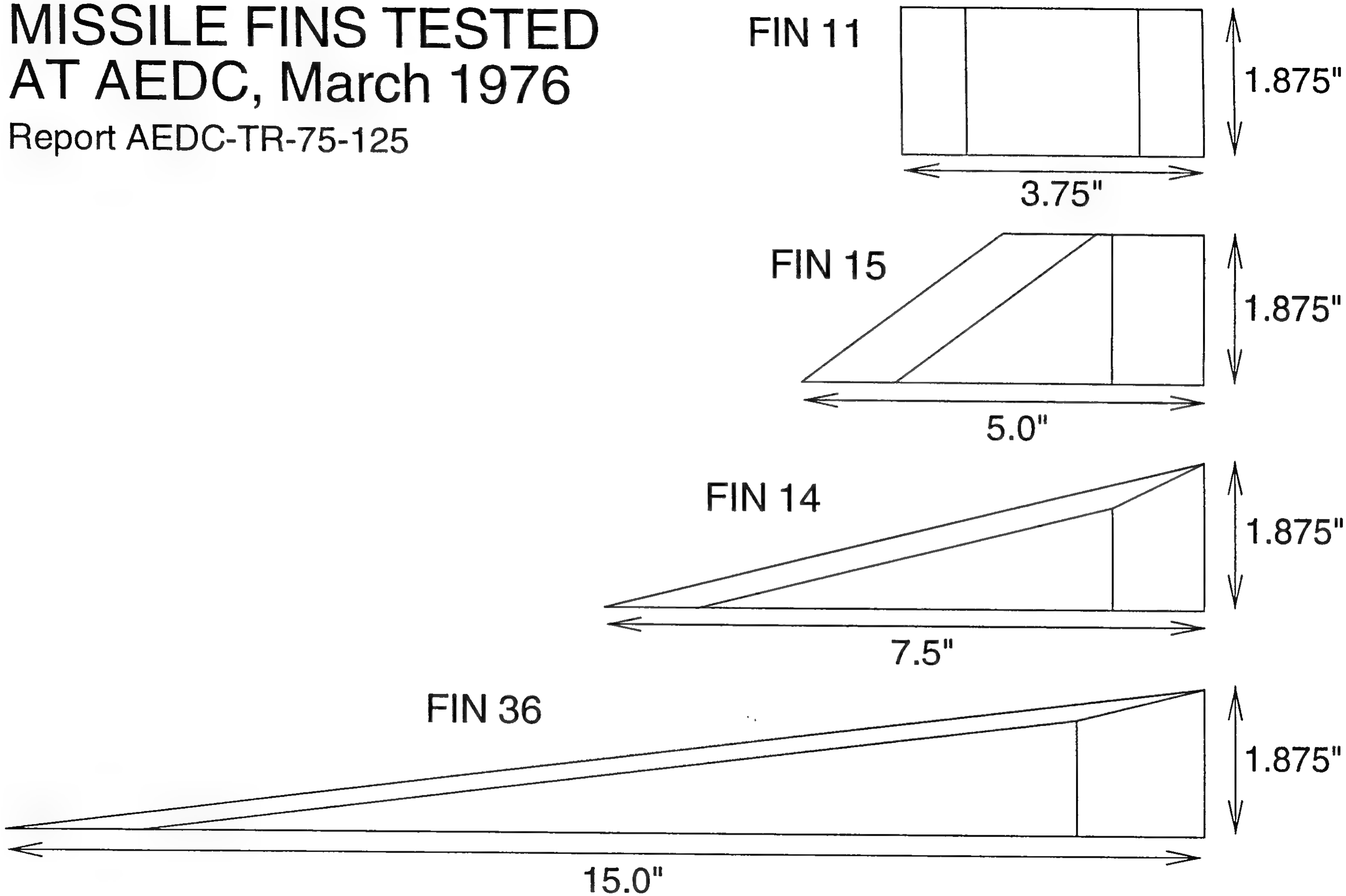


FIGURE 3

Subsonic Fin Center of Pressure Comparison, AEDC data, Fin 11, M=0.8

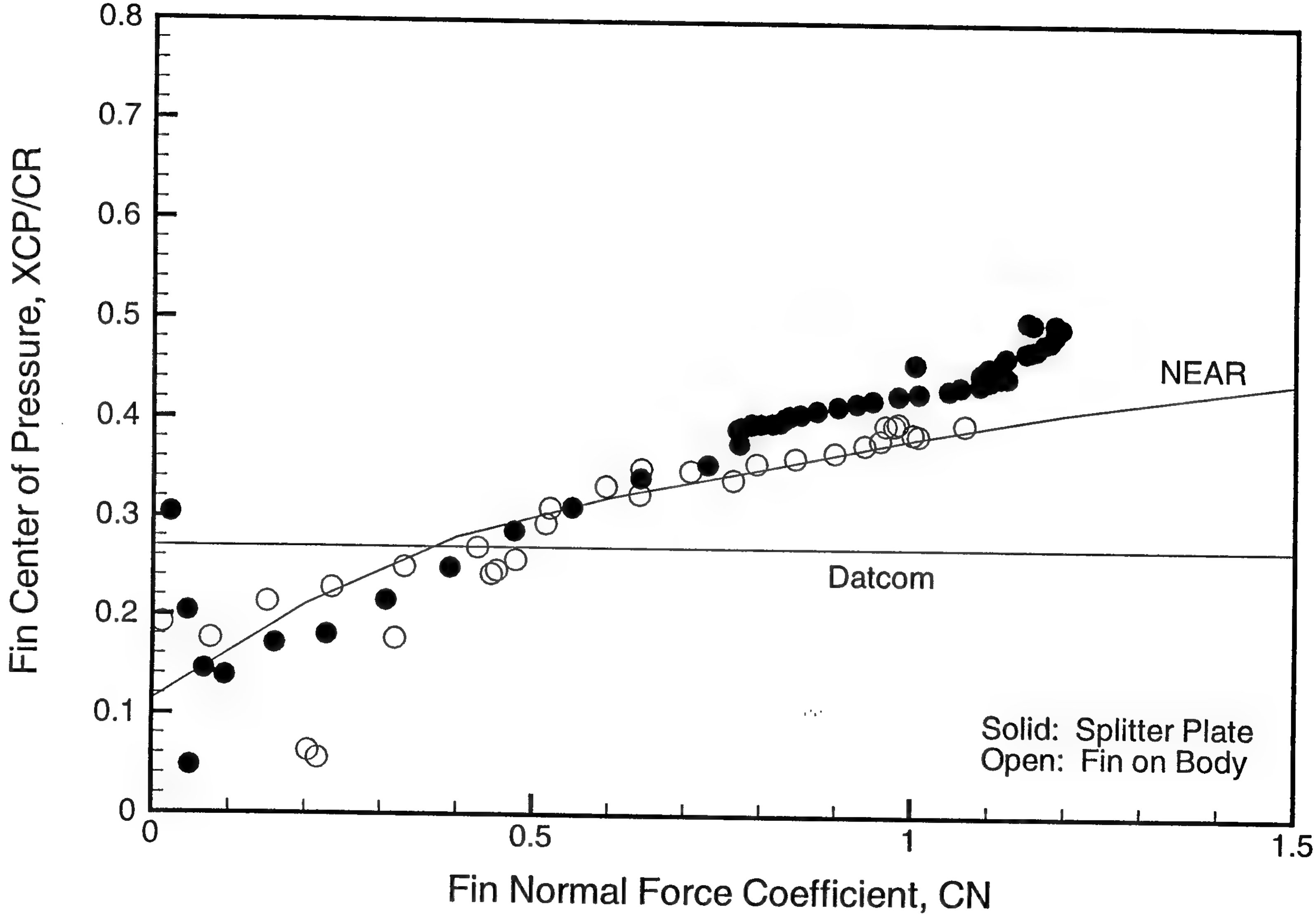


FIGURE 4

Subsonic Fin Center of Pressure Comparison, AEDC data, Fin 14, M=0.8

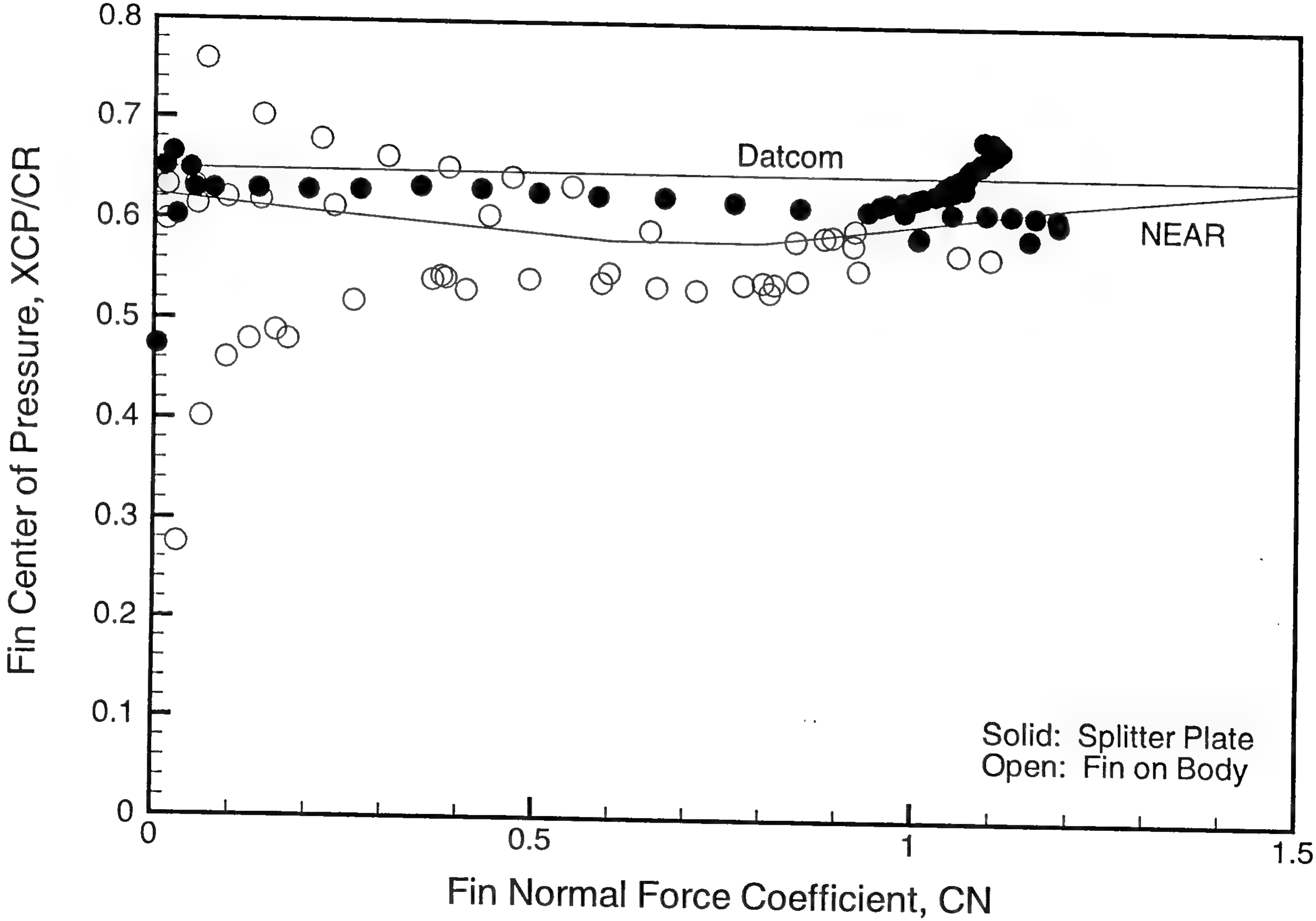


FIGURE 5

Subsonic Fin Center of Pressure Comparison, AEDC data, Fin 15, M=0.6

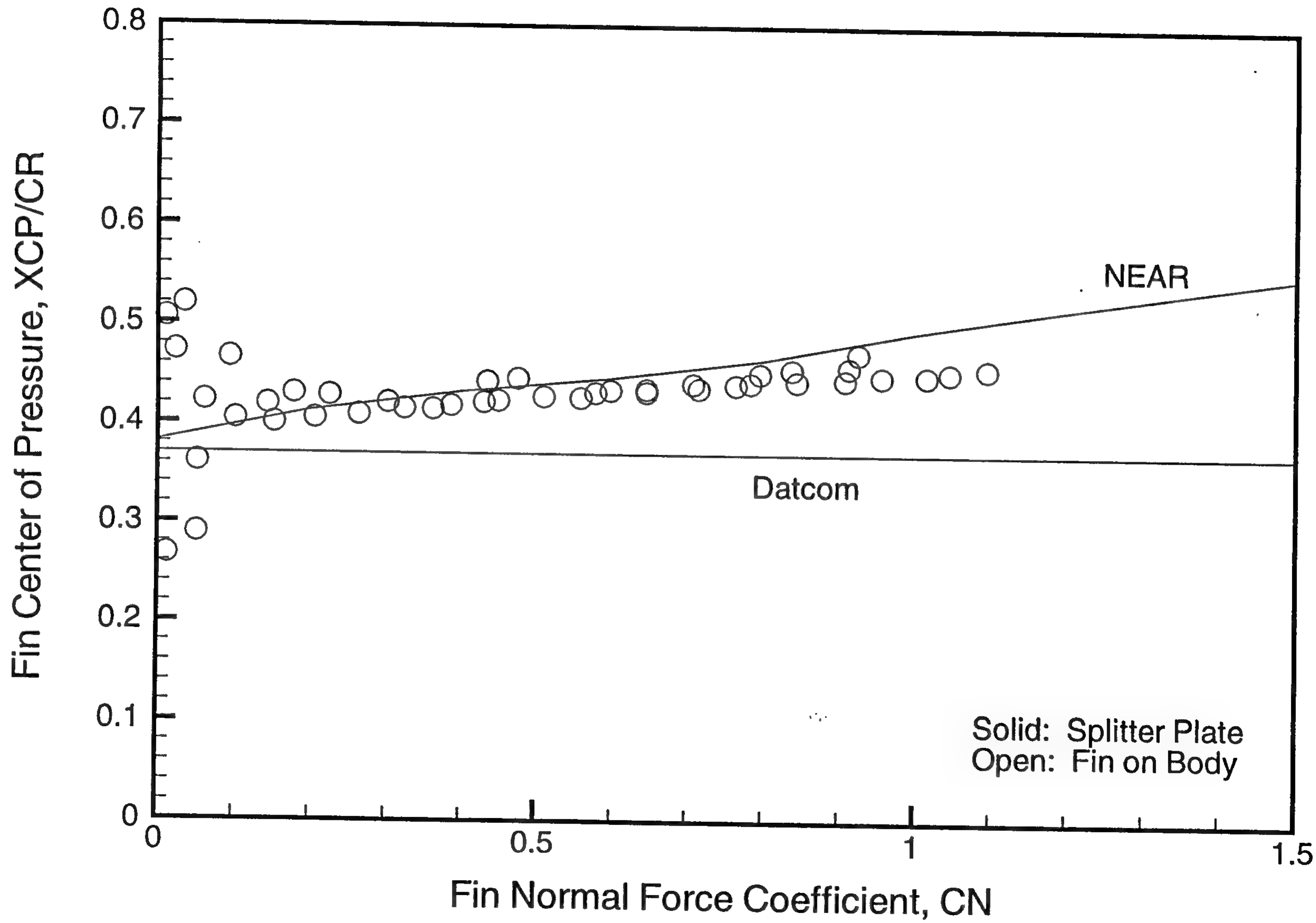


FIGURE 6

Subsonic Fin Center of Pressure Comparison, AEDC data, Fin 36, M=0.8

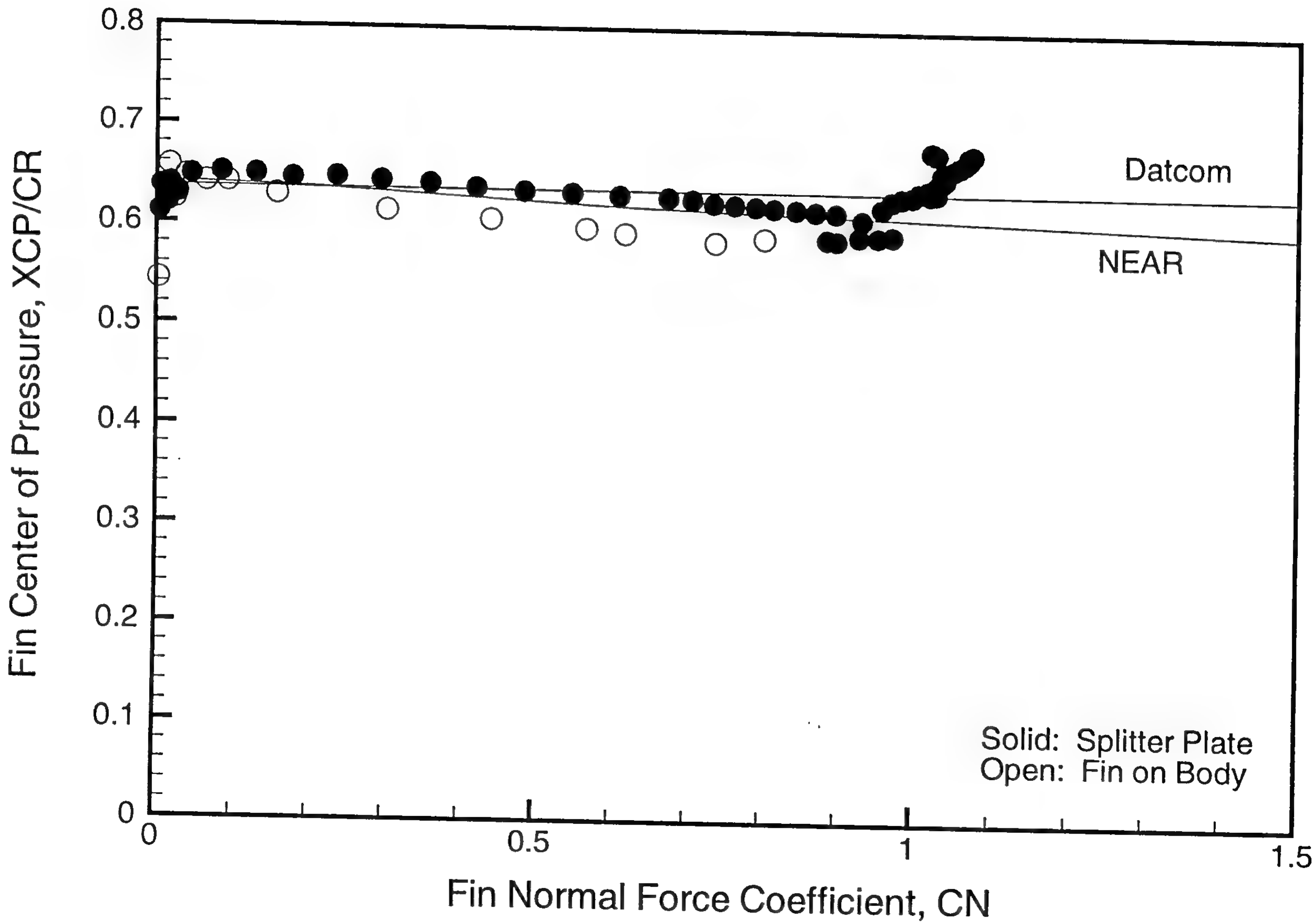
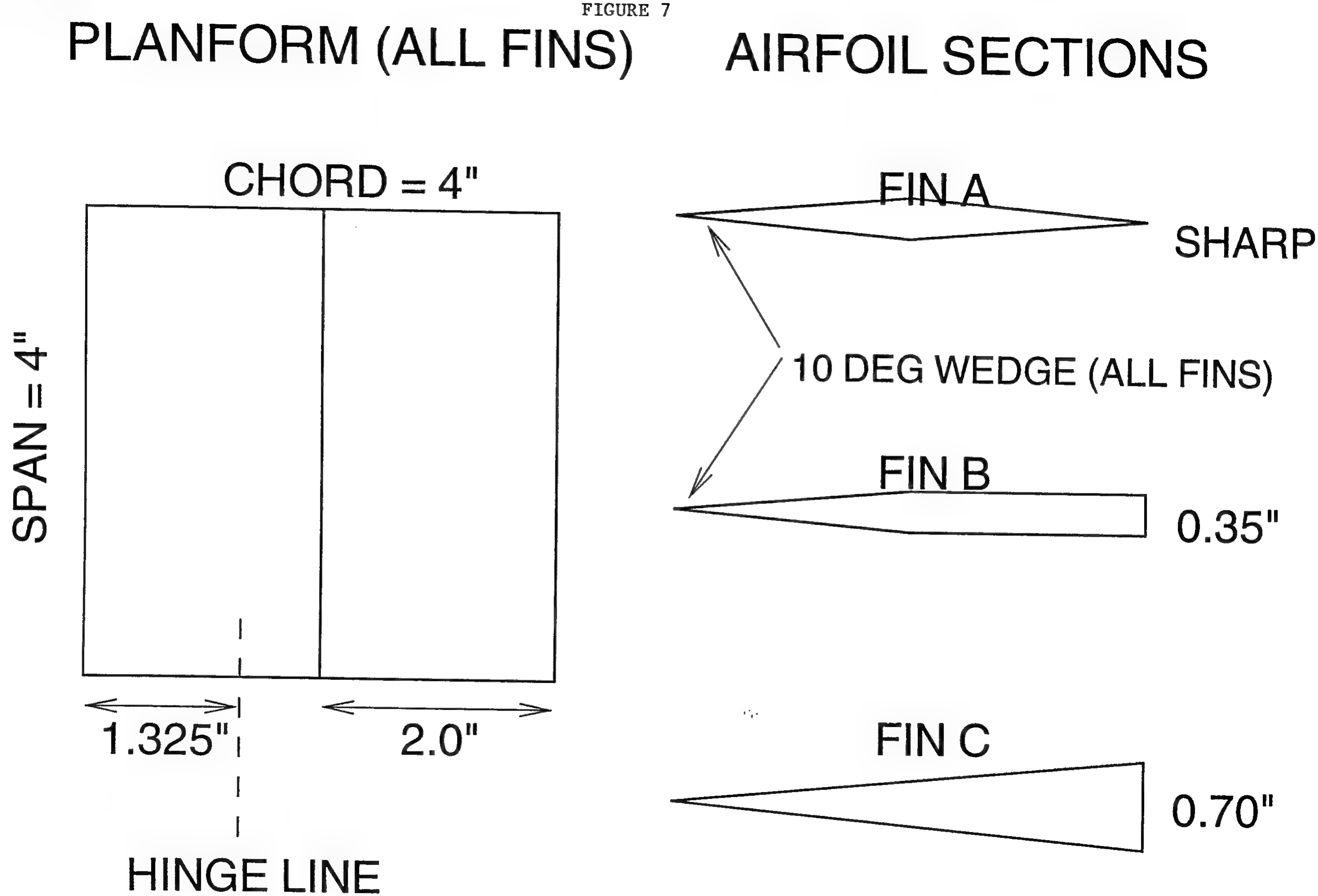


FIGURE 7



PLANFORM (ALL FINS)
AIRFOIL SECTIONS
CHORD = 4"
SPAN = 4"
1.325"
2.0"
HINGE LINE
FIN A
SHARP
10 DEG WEDGE (ALL FINS)
FIN B
0.35"
FIN C
0.70"

FIGURE 8

Subsonic Fin Center of Pressure Comparison, SARL data, Fin A, M=0.35

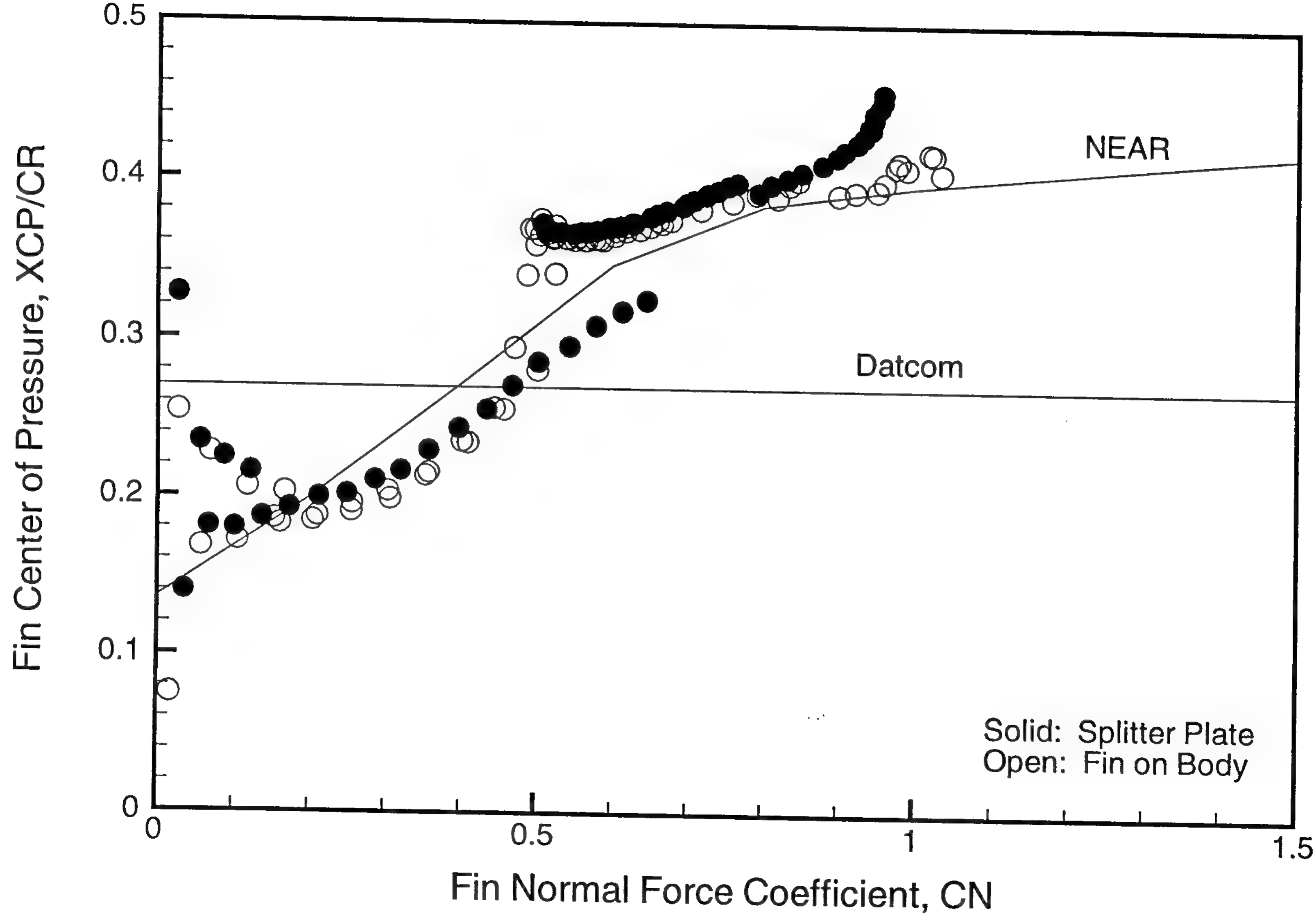


FIGURE 9

Subsonic Fin Center of Pressure Comparison, SARL data, Fin B, M=0.35

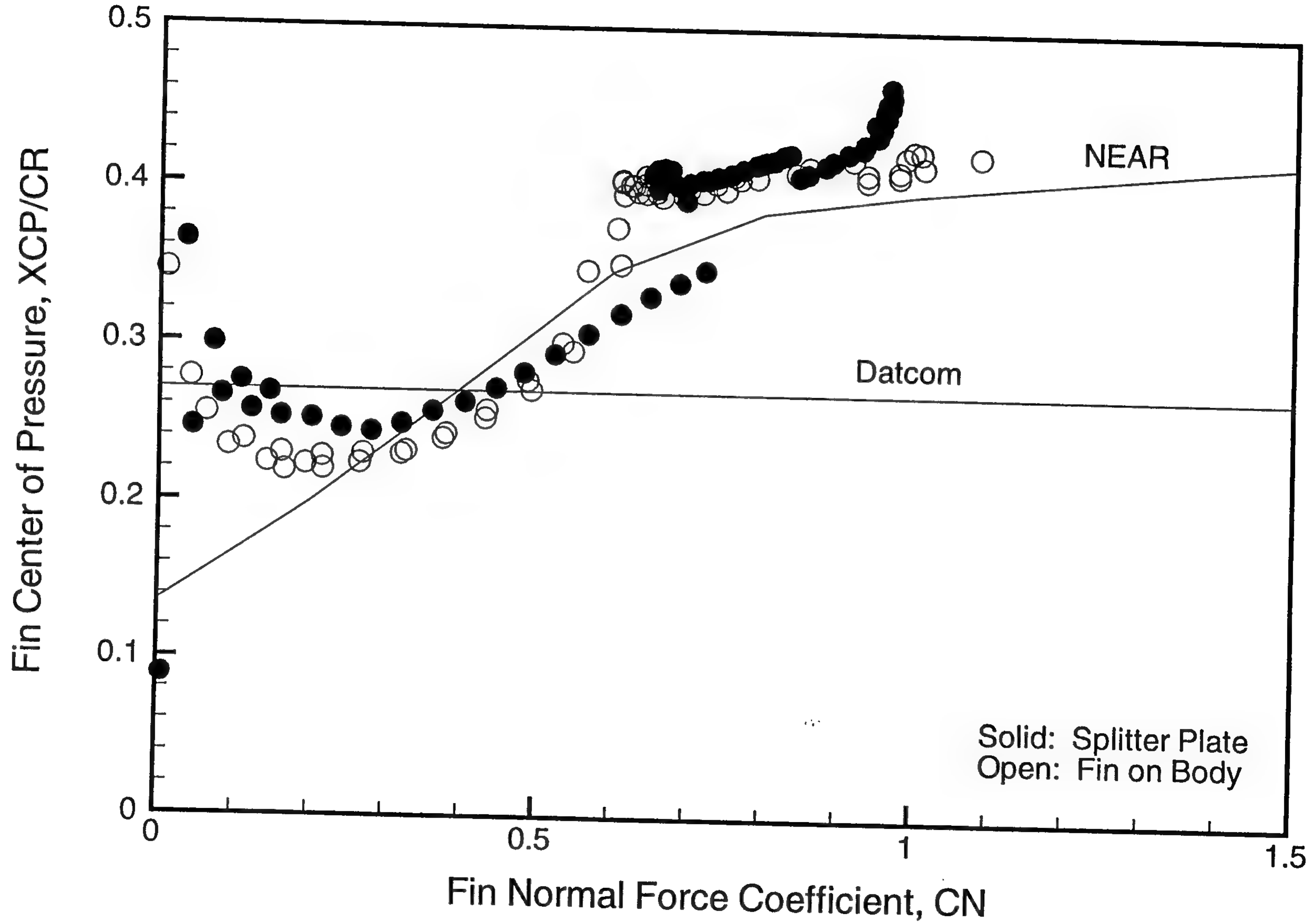
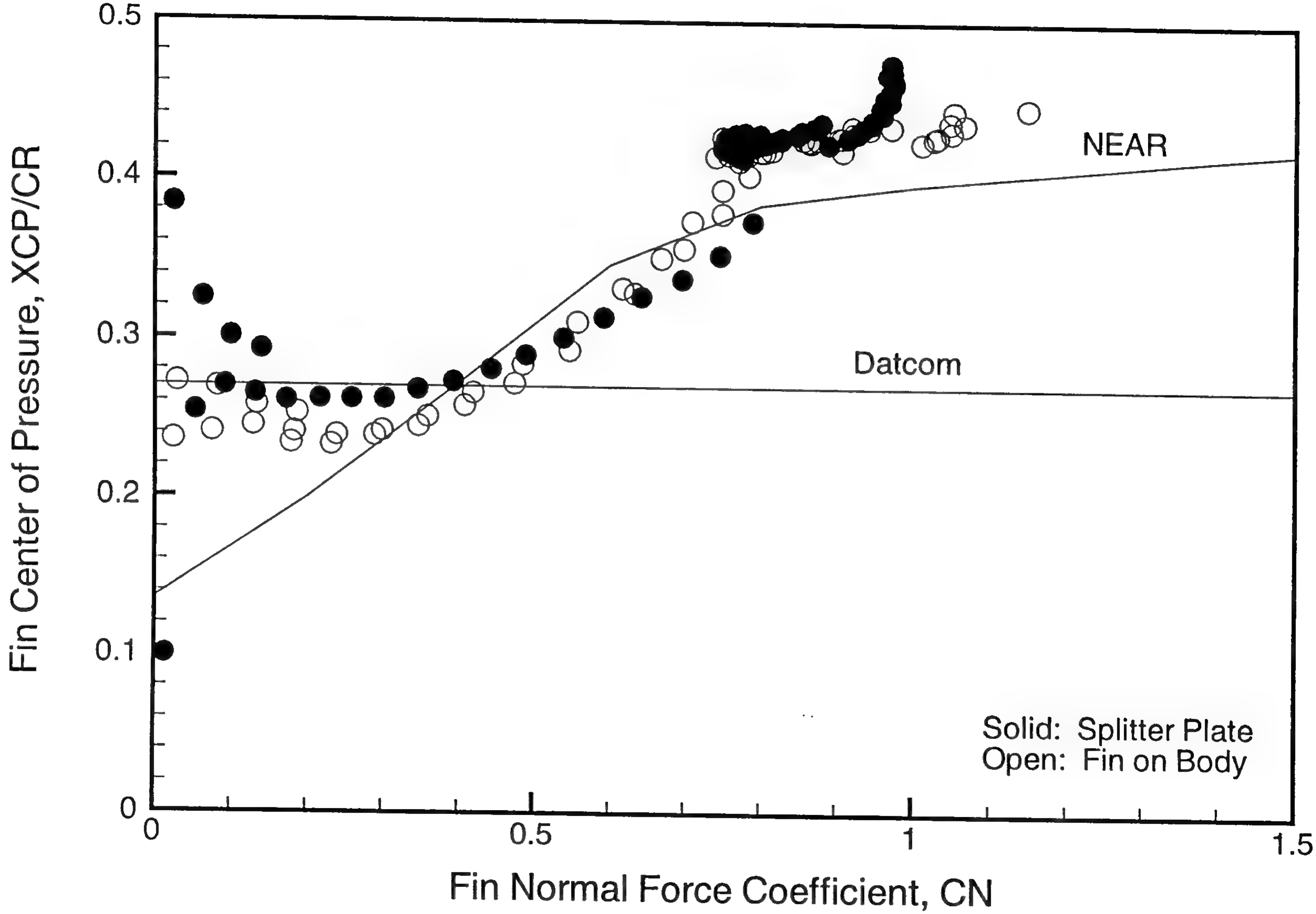


FIGURE 10

Subsonic Fin Center of Pressure Comparison, SARL data, Fin C, M=0.35



NANOPARTICLE DOPED ORGANIC ELECTRONIC JUNCTION DEVICES

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Final Report for:
High School Apprentice Program
Wright Laboratory Armament Directorate

Sponsored by:
Air Force Office of Scientific Research
Bolling Air Force Base, Washington D.C.

August 1997

Nanoparticle Doped Organic Electronic Junction Devices

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Abstract

Scientists have recently discovered that polymers could be synthesized so that they would be conductive of electricity. The polymers could be used to make organic electronic junction devices. The goal of this project was to create an organic p-n junction. This was attempted by depositing n-type doped polypyrrole on top of p-type polypyrrole. A colloidal suspension of antimony tin oxide was used to dope the polypyrrole film n-type. These bilayer films were then tested to see id a p-n junction resulted.

Introduction:

Plastics have revolutionized materials engineering by creating substances that are light, durable, easily shaped, and still maintain a strength necessary for practical use. They have opened up whole new worlds of possibilities, one of the most recent being in the realm of electronics with the discovery of inherently conductive polymers. In this new era of polymeric development there is much to learn and many possibilities to explore, with benefits already including rechargeable batteries that don't rely on chemical reactions, smart windows that turn opaque in the sun[1], and lastly the obvious advantage of light weight plastic electronic devices in contrast to the relative bulk of metal ones.

Discussion of problem:

Polypyrrole forms a p-type material with most dopants, such as dodecylbenzenesulfonate and toluenesulfonic acid. Tin oxide is an n-type material and if it were possible to dope polypyrrole with tin oxide, an n-type semiconductive film should be achievable. If this n-type film were deposited on a p-type film, a p-n junction would

be the result. The purpose of this study was to determine if it is possible to dope a polypyrrole film with tin oxide, specifically tin oxide nanoparticles suspended in a colloidal suspension; and to study the effects of junctions resulting from depositions on stainless steel and p-type polypyrrole films.

Methodology:

Research took place in three basic stages, characterized by the contents of the solutions used to grow the films, all of which contained pyrrole: first, plain Nyacol and different dilutions of Nyacol, next Nyacol with aqueous ammonia(ammonia-D) to counteract the gelling agents of the Nyacol, and lastly other dopants used in small amounts to increase the quality of the films(either with or without ammonia-D.) Electrochemical deposition took place in a plastic vessel containing a lead cathode and a stainless steel anode. The surface area of the anode and thus the surface area of the film was controlled by using kapton tape to prevent deposition in unwanted areas.

In the first stage solutions were made that ranged from undiluted Nyacol to 1 part Nyacol, 5 parts water. Current density of .75 mA/cm^2 and a deposition time of 10 to 15 minutes was used for all solutions with the exception of 1 part Nyacol, 5 parts water, in

which a current density of 1 mA/cm^2 and a deposition time of 50 minutes (interrupted every 10 minutes to swab off any gel that formed.) Tests with solutions ranging from pure Nyacol to 1 part Nyacol, 4 parts water contained no pyrrole and were performed to determine the dilution necessary for minimum gel formation. In the solution with 1 part Nyacol, 5 parts water, .05, .1, and .13 molar concentrations of pyrrole were used. Finally, solutions with molar concentrations of tin oxide(in Nyacol) were used (.01 M, .05 M, and .1 M) which correlated to approximately 1 part Nyacol in 11 parts water. These films were deposited at 1 mA/cm^2 for 30 minutes and contained .1 M pyrrole.

In the second stage of experimentation, ammonia-D was added to hinder the gelling effects of the Nyacol, thereby aiding the growth of the polypyrrole film. First, solutions of Nyacol and ammonia-d were electrolyzed to determine what dilution of the Nyacol was necessary to prevent gelling. Next, .1 M concentration of pyrrole was added and depositions at 1 mA/cm^2 for 30 minutes were attempted.

The last part of the study examined use of other dopants to make a better quality film in an attempt to still retain an n-type film. First, toluenesulfonic acid (TSA) was added to ammonia-D to determine if the TSA could improve the film quality enough to cancel out the hindrance caused by the ammonia-D; the concentrations were .1 M pyrrole and a solution with .05 M and .1 M TSA was used. Next, Nyacol was added to provide n-type antimony-doped tin oxide. Finally, the ammonia-D was taken out (it was too

harsh on film growth) and the concentration of TSA was taken down to .02 M(which is the molar concentration needed to make the film have a conductivity of less then one siemen and thus make it semiconductive[2]) and put in a solution of dilute Nyacol(.1 M) and .05 M pyrrole. This was deposited on a p-type polypyrrole film made from a solution with .02 M TSA and .05 M pyrrole.

Dodecylbenzenesulfonate(DBS) was another dopant used in conjunction with the Nyacol to make a better quality film and attempt to retain n-type film character. A concentration of .01 M DBS, .05 M pyrrole, and .05 M Nyacol in water was used and the film was deposited on a polypyrrole film made from a solution of .05 M DBS in water at .66 mA/cm^2 for 30 minutes.

Results:

The experiments with just Nyacol and water did not yield any useful films with less dilution than 1 part Nyacol and 5 parts water. The .13 M pyrrole in 1 part Nyacol, 5 parts water yielded a thin black film underneath a gellike layer that demonstrated a MOS switching mechanism. Small dots of conductive silver paint were placed on the film so the probe could make good electrical contact. The electrical properties of the film were

analyzed with a Tektronix type 576 curve tracer. The film displayed no conductivity until 1.2 V, after which the film switched to a low resistance, or "on" state. After a time frame of approximately five minutes, the film switched back to an insulator and displayed the same behavior. Repeating the deposition procedure to produce a film with similar appearance, it was next tried to remove the gel layer by a careful scraping. When analyzed on the curve tracer, the film was an insulator until .6 V, it would then conduct until the voltage was taken back down below .6 V, and then change back into an insulator again. All the trials with ammonia-D and Nyacol resulted in thin rusty brown films that displayed very little or no conductivity.

The films grown in a solution of TSA and Nyacol displayed a more conductive non-ohmic behavior, and when deposited on a p-type polypyrrole film, no diode effect was observed The films grown in a solution of DBS and Nyacol and deposited on a p-type polypyrrole film showed an ohmic character and also showed no diode effect.

Conclusions:

The switching effect observed in the film produced by the .13 M pyrrole in 1 part Nyacol, 5 parts water can be explained by using the metal-oxide-semiconductor (MOS)

switching theory. The metal was the silver paint used to make electrical contact, the oxide was the thin layer of solidified Nyacol(containing tin oxide nanoparticles), and the semiconductor was the polypyrrole film. In a MOS switch, the thin oxide film acts as an insulator until a certain voltage is applied at which charge carriers push through and saturate the semiconductor making it considerably more conductive and thus making the entire device conductive[3]. In order for the device to switch back to an insulating state, the charge carriers must drain, and in the device produced in this experiment, no method for drain was available except the slow process of natural charge diffusion. Hence, once in the on position the switch took considerable time to turn back off.

In the bilayer consisting of a DBS doped film and a Nyacol and DBS doped film the DBS overpowered the n-type Nyacol and a plain DBS doped film is too conductive, making it semimetallic rather than semiconductive[4]. The lack of a diode effect with the junction of the p-type TSA doped polypyrrole film and the film made from the solution of TSA and Nyacol indicates that the film was not n-type and therefore not doped predominately by tin oxide. This can be explained by the effect of the TSA on the pH of the Nyacol solution; the pH of Nyacol is instrumental in maintaining suspension of the colloidal tin oxide nanoparticles. If the pH is taken down to below 4 or 5 pH, the nanoparticles fall out of suspension and sink to the bottom[5]: as little as .02 M TSA brings the pH down to 1.6, much too acidic to maintain a colloidal suspension.

The purpose of this study was to determine if pyrrole could be doped n-type with a suspended solution of tin oxide nanoparticles and measure the current versus voltage characteristics formed from using p-type polypyrrole substrates. Polypyrrole electropolymerization was shown to be incompatible with this type of n-type doping due to its relatively low oxidation state. In addition, the Nyacol solution produced a gel that interfered with film growth to a degree that the solution had to be modified with substances that were strong p-type dopants in order to obtain adequate film growth. In all cases, the presence of p-type dopant necessary for polypyrrole film deposition more than compensated for the effects of any n-type tin oxide nanoparticles embedded in the films.

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5. Dr. Swank (private communication)

WEB PAGE DESIGN TO DISPLAY INFRARED IMAGERY

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Final Report for:
High School Apprentice Program
Wright Laboratory

Sponsored by:
Air Force Office of Scientific Research
Bolling Air Force Base, Washington, DC

And

Wright Laboratory

August 1997

WEB PAGE DESIGN TO DISPLAY INFRARED IMAGERY

Marcus MacNealy
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Abstract

Methods of displaying infrared imagery, collected for use with automatic target recognition technology, were studied. This imagery had to be coverted and placed on the internet. Allowing people access to the imagery required the development of an interface that was intuitive to use. Several designs were tried until a satisfactory one was found.

WEB PAGE DESIGN TO DISPLAY INFRARED IMAGERY

Marcus MacNealy

Introduction

The Automatic Target Recognition (ATR) Technology branch researches methods of identifying stationary and moving objects through the use of artificial intelligence. One possible technique involves the use of infrared (IR) imagery to use as a comparison to a target to identify it. The objective for this summer apprenticeship was to devise a way of displaying the IR imagery collected on the internet. Several issues needed to be addressed: image format, page layout, and interface design. The decisions made for each of these was influenced in part by work started during the previous summer.

Methodology

The IR imagery collected was archived on a CD-ROM disc in a 16-bit, signed integer backward byte binary image format. Although a simple format to use, most image processing programs available do not properly load in the file. Therefore, a program was written to read in multiple files and output them as 8-bit Windows-type bitmaps. It was acceptable to reduce the images from 16-bits to 8-bits because the majority of people viewing the images do not display more than 256 colors on their screen. Also, the reduction of color depth decreased the file size of the image, making it faster to transfer. Once converted to bitmap, the images could then be read by another program and converted to JPEG. The JPEG format is used because it is designed for efficiently storing images taken outside.

The fact that JPEG is a "lossy" format, meaning that some data is lost in the compression of the image, is not a concern.

The original method of accessing the images was to group the related pictures together in a hypertext markup language (HTML) file. This created the need of over 1500 HTML files, making it undesirable. However, this design was kept for two reasons. First, it allows compatibility with the original design and, second, is the easiest to implement.

Since the purpose of these web pages is to provide people with an easy way of accessing the IR images, the interface needed to be as intuitive as possible. Originally, the designed implemented tables inside frames. However, this is unsatisfactory for low-resolution displays, so it was changed to a toolbar at the top of the page to select the image to be displayed from a series of choices. The toolbar is dynamic, so that one choice affects what the next choice will be. This required the use of JavaScript to load multiple HTML files at once. The first implementation of the toolbar consisted of four pulldown boxes, each containing a choice for the user. However, the use of a pulldown box required two mouse clicks, so the interface was modified to use hyperlink references, so that the menus would require only one click. This modification made the interface intuitive enough for people to use effectively.

Results

In spite of this project requiring the conversion of approximately 1500 IR images, it was completed in the time allotted by writing a computer program to automate the task. Another computer program was used

to automate the creation of over 1200 HTML files. This expedited the completion of the work started last year, which was done manually. Figure 1 shows an example web page, displaying both the revised interface and IR imagery. Through the toolbar, the user can access all of the IR imagery through making four selections.

Conclusion

The new method of presenting the IR imagery meets the objective set forth. All of the IR imagery is accessible through the web site, using the new interface. The page layout could be improved with more time, so that the number of files needed to display the data is decreased. Overall, the new design is an improvement over the work initiated last year.

THE INTEGRATION OF CIRCUIT SYNTHESIS AND SCHEMATIC PROGRAMS USING PROLOG, AND EVALUATION OF A GRAPHICAL INTERPRETATION OF FRACTIONAL ORDER DERIVATIVES

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Final Report for:
High School Apprentice Program
Wright Patterson Air Force Base

Sponsored by:
Air Force Office of Scientific Research
Bolling Air Force Base, DC

and

Wright Patterson Air Force Base

July 1997

THE INTEGRATION OF CIRCUIT SYNTHESIS AND SCHEMATIC PROGRAMS USING PROLOG, AND EVALUTATION OF A GRAPHICAL INTERPRETATION OF FRACTIONAL ORDER DERIVATIVES

Jonathan Mah
Centerville High School

Abstract

Prolog, a logic programming tool, was used to take the circuit netlist from SPICE (Simulation Program with Integrated Circuit Emphasis) and convert it to a schematic diagram in CIRC. Prolog creates a type of "tree" logic where each variable, such as a resistor or capacitor, is found and put into memory. This information is then retrieved by means of backtracking to interpret the list into a circuit diagram in CIRC. In addition to this project, an interpretation of fractional derivatives graphically was evaluated using Maple V. The approach taken was, instead of having the x and y components of the derivative meeting at a 90° angle for the slope of a given function, the angle was variable. By changing the angle, a more drawn out function is reached.

THE INTEGRATION OF CIRCUIT SYNTHESIS AND SCHEMATIC PROGRAMS USING PROLOG

Jonathan Mah

Introduction

SPICE is a common tool in the area of circuit design and analysis. It takes a series of different circuit components and synthesizes the entire circuit using nodes to determine their positions. The problem is that there is no public domain version that can draw the schematic. CIRC is a drawing tool in Latex that has good circuit graphics but is a very different language than that of SPICE. This is where Prolog is useful. Prolog programming is different from other programming languages like Fortran, because it uses goals to accomplish tasks instead of long routines and subroutines. It "thinks" by way of the different definitions of functions that are programmed into its library, it then goes through a systematic process of matching the goal to a certain route through the definitions. Its use in this particular problem is that it can interpret the SPICE language into that of CIRC and also make sure that the drawing is accurate and not overlapping.

Methodology

The first step in integrating the two programs is to translate the SPICE script into what it means in plain language. In figure 1, a simple SPICE input and output script is shown. The first term on the line tells SPICE what component is being inserted. The next two terms are numbers saying to what two nodes the component is connected. The last term is the value of the component. According to the nodal connection, SPICE knows whether the components are connected in series or parallel.

Figure 1

Transient Response of a Linear Network

```
****    INPUT LISTING                TEMPERATURE =  27.000 DEG C

 ** Circuit Description **
* input signal source
Vi 1 0 SIN( 0V 10V 60Hz )
* linear network
R1    1 2 1Ohm
C1    2 0 2.65mF
Rload 3 0 10Ohm
E1 3 0 2 0 10
```

```
** Analysis Request **
* compute transient response of circuit over three full
* periods (50 ms) of the 60 Hz sine-wave input with a 1 ms
* sampling interval
.TRAN 1ms 50ms 0ms 1ms

** Output Request **
* print the output and input time-varying waveforms
.PRINT TRAN V(3) V(1)
* plot the output and input time-varying waveforms
* set the range of the y-axis between -100 and +100 V
.PLOT TRAN V(3) V(1) (-100,+100)

* indicate end of Spice deck
.end

Transient Response of a Linear Network

****     INITIAL TRANSIENT SOLUTION     TEMPERATURE =  27.000 DEG C

 NODE  VOLTAGE   NODE  VOLTAGE   NODE  VOLTAGE
( 1)  0.0000   ( 2)  0.0000  ( 3)  0.0000
VOLTAGE SOURCE CURRENTS
   NAME     CURRENT
   VI      0.000E+00
   TOTAL POWER DISSIPATION  0.00E+00  WATTS

Transient Response of a Linear Network

****     OPERATING POINT INFORMATION     TEMPERATURE =  27.000 DEG C

**** VOLTAGE-CONTROLLED VOLTAGE SOURCES
        E1
V-SOURCE    0.000
I-SOURCE  0.00E+00

Transient Response of a Linear Network

****     TRANSIENT ANALYSIS          TEMPERATURE =  27.000 DEG C

   TIME       V(3)       V(1)
X
 0.000E+00   0.000E+00  0.000E+00
 1.000E-03   6.252E+00  3.680E+00
 2.000E-03   2.152E+01  6.755E+00
 3.000E-03   3.962E+01  8.888E+00
 4.000E-03   5.671E+01  9.804E+00
 5.000E-03   6.910E+01  9.342E+00
 6.000E-03   7.400E+01  7.568E+00
 7.000E-03   7.003E+01  4.732E+00
 8.000E-03   5.727E+01  1.231E+00
 9.000E-03   3.716E+01 -2.443E+00
 1.000E-02   1.232E+01 -5.774E+00
 1.100E-02  -1.426E+01 -8.413E+00
```

1.200E-02	-3.821E+01	-9.663E+00
1.300E-02	-5.676E+01	-9.661E+00
1.400E-02	-6.725E+01	-8.302E+00
1.500E-02	-6.825E+01	-5.777E+00
1.600E-02	-5.963E+01	-2.441E+00
1.700E-02	-4.261E+01	1.238E+00
1.800E-02	-1.969E+01	4.796E+00
1.900E-02	6.592E+00	7.682E+00
2.000E-02	3.200E+01	9.503E+00
2.100E-02	5.275E+01	9.972E+00
2.200E-02	6.619E+01	9.041E+00
2.300E-02	7.038E+01	6.841E+00
2.400E-02	6.474E+01	3.679E+00
2.500E-02	5.003E+01	9.962E-04
2.600E-02	2.831E+01	-3.677E+00
2.700E-02	2.622E+00	-6.845E+00
2.800E-02	-2.357E+01	-9.010E+00
2.900E-02	-4.577E+01	-9.832E+00
3.000E-02	-6.171E+01	-9.367E+00
3.100E-02	-6.903E+01	-7.586E+00
3.200E-02	-6.668E+01	-4.739E+00
3.300E-02	-5.498E+01	-1.227E+00
3.400E-02	-3.558E+01	2.457E+00
3.500E-02	-1.118E+01	5.796E+00
3.600E-02	1.512E+01	8.434E+00
3.700E-02	3.875E+01	9.657E+00
3.800E-02	5.711E+01	9.659E+00
3.900E-02	6.749E+01	8.304E+00
4.000E-02	6.843E+01	5.783E+00
4.100E-02	5.977E+01	2.450E+00
4.200E-02	4.274E+01	-1.228E+00
4.300E-02	1.971E+01	-4.732E+00
4.400E-02	-6.328E+00	-7.705E+00
4.500E-02	-3.166E+01	-9.463E+00
4.600E-02	-5.239E+01	-9.932E+00
4.700E-02	-6.582E+01	-9.007E+00
4.800E-02	-7.004E+01	-6.816E+00
4.900E-02	-6.445E+01	-3.668E+00
5.000E-02	-5.002E+01	-1.419E-13

Transient Response of a Linear Network

**** TRANSIENT ANALYSIS TEMPERATURE = 27.000 DEG C

LEGEND:

*: V(3)
+: V(1)

TIME V(3)

```
(*+)---------- -1.000E+02   -5.000E+01   0.000E+00   5.000E+01  1.000E+02
               ----------------------------
0.000E+00 0.000E+00 .      .        X       .       .
```

```
1.000E-03  6.252E+00 .        .        .+*        .         .
2.000E-03  2.152E+01 .        .        .+   *     .         .
3.000E-03  3.962E+01 .        .        .+       * .         .
4.000E-03  5.671E+01 .        .        .+         .*        .
5.000E-03  6.910E+01 .        .        .+         .   *     .
6.000E-03  7.400E+01 .        .        .+         .    *    .
7.000E-03  7.003E+01 .        .        .+         .   *     .
8.000E-03  5.727E+01 .        .        .+         .*        .
9.000E-03  3.716E+01 .        .        .+      *  .         .
1.000E-02  1.232E+01 .        .        .+ *       .         .
1.100E-02 -1.426E+01 .        .      * .+         .         .
1.200E-02 -3.821E+01 .        .  *     .+         .         .
1.300E-02 -5.676E+01 .       *.        .+         .         .
1.400E-02 -6.725E+01 .     *  .        .+         .         .
1.500E-02 -6.825E+01 .    *   .        .+         .         .
1.600E-02 -5.963E+01 .      * .        .+         .         .
1.700E-02 -4.261E+01 .        .*       .+         .         .
1.800E-02 -1.969E+01 .        .     *  .+         .         .
1.900E-02  6.592E+00 .        .        .X         .         .
2.000E-02  3.200E+01 .        .        .+     *   .         .
2.100E-02  5.275E+01 .        .        .+         .*        .
2.200E-02  6.619E+01 .        .        .+         .  *      .
2.300E-02  7.038E+01 .        .        .+         .   *     .
2.400E-02  6.474E+01 .        .        .+         .  *      .
2.500E-02  5.003E+01 .        .        .+         *         .
2.600E-02  2.831E+01 .        .        .+     *   .         .
2.700E-02  2.622E+00 .        .        .+*        .         .
2.800E-02 -2.357E+01 .        .    *   .+         .         .
2.900E-02 -4.577E+01 .        .*       .+         .         .
3.000E-02 -6.171E+01 .      * .        .+         .         .
3.100E-02 -6.903E+01 .    *   .        .+         .         .
3.200E-02 -6.668E+01 .     *  .        .+         .         .
3.300E-02 -5.498E+01 .       *.        .+         .         .
3.400E-02 -3.558E+01 .        .  *     .+         .         .
3.500E-02 -1.118E+01 .        .       *.+         .         .
3.600E-02  1.512E+01 .        .        .+ *       .         .
3.700E-02  3.875E+01 .        .        .+       * .         .
3.800E-02  5.711E+01 .        .        .+         .*        .
3.900E-02  6.749E+01 .        .        .+         .  *      .
4.000E-02  6.843E+01 .        .        .+         .   *     .
4.100E-02  5.977E+01 .        .        .+         . *       .
4.200E-02  4.274E+01 .        .        .+        *.         .
4.300E-02  1.971E+01 .        .        .+   *     .         .
4.400E-02 -6.328E+00 .        .        .X         .         .
4.500E-02 -3.166E+01 .        .   *    .+         .         .
4.600E-02 -5.239E+01 .        *        .+         .         .
4.700E-02 -6.582E+01 .     *  .        .+         .         .
4.800E-02 -7.004E+01 .    *   .        .+         .         .
4.900E-02 -6.445E+01 .     *  .        .+         .         .
5.000E-02 -5.002E+01 .        *        .+         .         .
                     ------------------------------
```

The next step is to create a system of definitions so that Prolog can understand where the components are located and what their values are. This is done by assigning definitions such as "ser" for series and "par"

for parallel. Before going any further, a few clarifications about the Prolog language must be addressed. An example script is shown in figure 2 Prolog commands are in the form "command(Variable, atom, . . .)" where atoms are fixed values and variables are not. All variables in Prolog are capitalized or preceded by an underscore, and atoms are numbers or are not capitalized.

<u>Figure 2</u>

```
% The way plan is decomposed into stages by conc, the precondition plan (PrePlan)
% is found in breadth-first fashion. However, the length of the rest of plan is not
% restricted and goals are achieved in depth-first style.

plan(State,Goals,Plan,FinalState) :-
  conc(PrePlan,[Action | PostPlan], Plan),        % Divide plan
  select(State,Goals,Goal),                       % Select a goal
  achieves(Action,Goal),
  can(Action,Condition),
  plan(State,Condition,PrePlan,MidState1),
  apply(MidState1,Action,MidState2),
  plan(MidState2,Goals,PostPlan,FinalState).

% satisfied(State,Goals): Goals are true in State

satisfied(State,[]).

satisfied(State,[Goal | Goals]) :-
  member(Goal,State),                             % Usual list membership
  satisfied(State,Goals).

select(State,Goals,Goal) :-
  member(Goal,Goals),
  not_member(Goal,State).                         % Goal not satisfied

% achieves(Action,Goal): Goal is in the add-list of Action

achieves(Action,Goal) :-
  add(Action,Goals),
  member(Goal,Goals).

% apply(State,Action,NewState):
%   Action executed in State produces NewState

apply(State,Action,NewState) :-
  del(Action,DelList),
  delete(State,DelList,State1),!,
  add(Action,AddList),
  conc(AddList,State1,NewState).

% delete(L1,L2,Diff): Diff is set-difference of lists L1 and L2

delete([],_,[]).
```

```
delete([X|L1],L2,Diff) :-
  member(X,L2),!,
  delete(L1,L2,Diff).

delete([X|L1],L2,[X|Diff]) :-
  delete(L1,L2,Diff).
```

Once all the definitions are assigned for the various components of the circuit, Prolog can begin to translate the language to that of CIRC. An example script of CIRC is in figure 3.

Figure 3

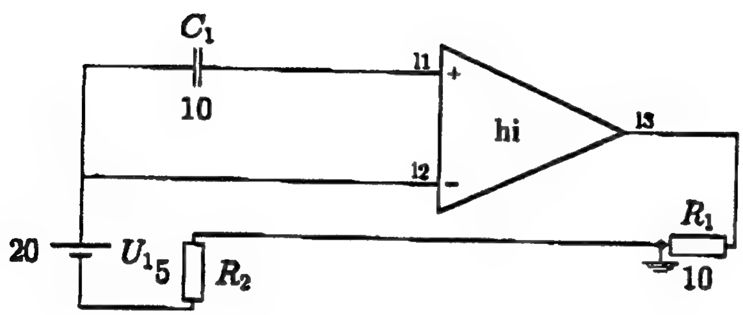
```
\documentclass[12pt,doublespace,epsfig]{article}
\usepackage[basic,box,gate,ic,optics]{circ}

\begin{document}
\begin{center}
\begin{circuit}0
\ov12 hi 9 1 2 3
\frompin npn1C
\- 1 u
\nl\A1 {$I_C$} v
\atpin npn1B
\- 1 l
\<\R1 {$\beta$} h
\- 1 l
\centerto A1
\nl\A2 {$I_B$} v
\frompin A2d
\vtopin R1l
\frompin A1u
\- 1 u
\.1
\frompin A2u
\vtopin .1
\htopin .1
\- 1 u
\cc\connection1 {$U_b$} u
\frompin npn1E
\- 1 d
\GND1
\end{circuit}
\end{center}
\end{document}
```

The difficulty in this translation is that Prolog must enter commands such that CIRC will draw them with the appropriate length wires. Otherwise CIRC will just draw the components on top of each other. The best way to compensate for this is to give Prolog a certain radius around each component to draw wires.

When this is accomplished, Prolog will be able to translate entire scripts of SPICE to CIRC. An example of CIRC's drawing capability is located in figure 4.

Figure 4



A GRAPHICAL INTERPRETATION
OF FRACTIONAL DERIVATIVES

In the realm of derivatives, we learn to differentiate integer order derivatives (1st derivative, 2nd derivative, etc.). Fractional order derivatives have been pondered since Leibniz (1695). One difference between integer order and fractional order derivatives is that a graphical representation is not yet found for fractional order derivatives. Another difference is that there is no standard form for performing fractional order derivatives. One graphical interpretation is to look at the slope for a regular, first-order derivative and manipulate the angle that binds the change in x and the change in y. Looking at the right triangle in figure 5, we see that:

$$y := r\sin(t)$$

Consequently,

$$dy = \sin(t)\,dr + r\cos(t)\,dt$$

and,

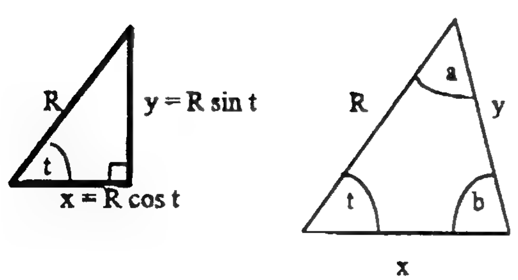
$$x := r\cos(t)$$

$$dx = \cos(t)\,dr - r\sin(t)\,dt$$

So for the right triangle, we see that the derivative is,

$$\frac{dy}{dx} = \frac{\sin(t)\,dr + r\cos(t)\,dt}{\cos(t)\,dr - r\sin(t)\,dt}$$

Figure 5



Now, looking at the triangle with b not equal to 90 degrees, I used the Law of Sines to show,

$$x = \frac{y \sin(a)}{\sin(t)}$$

$$y = \frac{x \sin(t)}{\sin(a)}$$

and using the quotient rule,

$$dx = \frac{\sin(t)\,(dy \sin(a) + y \cos(a)) - y \sin(a) \cos(t)}{\sin(t)^2}$$

$$dy = \frac{\sin(a)\,(dx \sin(t) + x \cos(t)) - x \sin(t) \cos(a)}{\sin(a)^2}$$

Thus,

$$\frac{dy}{dx} = \frac{(\sin(a)\,(dx \sin(t) + x \cos(t)) - x \sin(t) \cos(a)) \sin(t)^2}{\sin(a)^2\,(\sin(t)\,(dy \sin(a) + y \cos(a)) - y \sin(a) \cos(t))}$$

Graphically, I believe that with b being less than 90 degrees, the graph of any function will be more drawn out. These different representations of functions can possibly show other relationships between functions. They will tell something different about the function. Fractional calculus is actually used in linear system state formulations, corrosion, fractals and chaos, but these definitions are not simple and widely understood. This is a very interesting subject and it requires one to think in ways contrary to those of conventional calculus.

TERMINAL BALLISTICS DATA ACQUISITION AND ANALYSIS

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Final Report for:
High School Apprentice Program
Wright Laboratory

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Bolling Air Force Base, Washington, DC

And

Wright Laboratory

August 1997

Terminal Ballistics Data Acquisition and Analysis

David Mandel
Niceville High School

Abstract

In this project the goal was to create a database for a large bore, high velocity launcher so that a base data set could be available for any further testing which may be done with this particular gun. The gun used was a 127mm cannon removed from a tank with an extra barrel added. Several shots were fired varying the projectile mass and make up, the armor type and thickness, the powder charge, the launch package mass, and other minor parameters. The shots were then fired and essential data was recovered such as barrel recoil, penetrator velocity, and even X-ray photographs were taken. All essential data was then entered into the computer for processing. Now when any further testing utilizes this launcher, the engineers have a database to look at when determining the parameters for their shot.

Terminal Ballistics Data Acquisition and Analysis

David Mandel

Introduction

When performing any set of tests on a gun of this caliber, engineers must first research the history of the gun much like a good student researches a science fair project. They look at previous research to get a background of information. Thus before performing any set of tests on a gun, engineers must have a database including many test shots to determine of parameters for the gun including optimum launch package size, powder charge, and projectile velocity.

Background

In order to understand much of the collected data, one much first understand how a gun of this caliber works. To begin we must look at the gun itself. The gun was originally a 120mm gun on a typical tank. However, when the gun was brought to this site it was bored out from 120mm to 127mm. In order to fire the penetrators at high velocity, a second barrel was attached to extend the time during which propellant gases can act on the base of the projectile. A tight seal must be had between the projectile and the barrel as well. This is the reason for the launch package. The launch package consists of four parts. These are the penetrator, the sabot, the obturator, and the pusher plate. The configuration of these items is crucial. The penetrator in surrounded by a plastic sheath called the sabot. This fills the extra barrel diameter and creates a good seal.

The sabot has tunnels dug into the front and groves cut down the side. This is so when is exits the barrel, air will enter and tear the sabot open. This is done for a reason that will be discussed shortly. The other two parts, the pusher plate and obturator, are also vital. The pusher plate is a metal plate that rests in the bottom of the sabot. It transmits the force from expanding propellant gases to the projectile. The obturator fits snugly on the bottom of he sabot as well. It forms an airtight seal between the propellant gases and the launch package. This allows the engineers to build up over 80,000 psi of pressure behind the launch package.

Once the launch package is fired the sabot tears open as mentioned before. Then, the whole package meets the stripper plate. This is a four-inch thick steel plate with a hole just larger than the penetrator bored in the center. The penetrator passes through this hole while the combination of the sabot, pusher plate, and obturator hit the stripper plate and are stopped. This is so they do not hit the armor and affect the shot. The penetrator passes through a second stripper plate to catch any excess material that may have made it past the first. It then hits the armor. The armor material, size, mass, thickness, and specific setup vary and will be discussed later in this paper. One thing common to all the armor in the test shots was that is was thin enough for the penetrator to pass through. The final step is that the penetrator must be stopped. Thus, a catching plate is used. This is a high-pressure slab of concrete several feet thick that brings the projectile to rest.

One other important aspect of the setup is the X-ray cameras. There are 2 sets of X-ray cameras used. Two shots immediately before the penetrator hits the armor are taken, each from a different known angle. This helps the engineer determine the yaw of the penetrator upon entering, a very important piece of data. The other two X-rays shoot as the penetrator exits the back of the armor to give even more data on fragmentation of the armor and other important parameters. All the shots are mere microseconds apart, yet provide a wealth of information important to this database and to any tests that may be performed in the future.

Methodology

Using Microsoft Access® a data acquisition table was set up. Below can be seen an exact replica of it.

127mm Armor Penetration Test Data

Round Number: [ ]

Date: [ ]

Time: [ ]

Elevation Before/After: [ ]

Recoil (in): [ ] Standoff Distance (ft): [ ]

Target Description: [ ]

Thickness (in): [ ] BHN: [ ] Obliquity Angle: [ ]

Projectile Description: [ ]

Penetrator L/D: [ ] Penetrator Diameter (in): [ ]

Projectile mass (gm): [ ] Sabot mass (gm): [ ]

Pusher mass (gm): [ ] Obturator mass (gm): [ ]

Total Launch Package mass (gm): [ ]

Powder Charge:

M30 weight (lbs.): [ ] M117 weight (lbs.): [ ]

Expected Velocity (km/s): [ ] Launch Package seated at (in): [ ]

Chamber Pressure: Cu sphere lot number [ ]

Gauge 1 number: [ ] Reading (in): [ ] Pressure 1 (psi): [ ]

Gauge 2 number: [ ] Reading (in): [ ] Pressure 2 (psi): [ ]

Data Acquisition table Continued:

Screen Velocity (km/s): [ ] X-ray velocity (km/s): [ ]

Aim Point: [ ]

Impact Point: [ ]

Pitch/Yaw Observations: [ ]

Penetration (in): [ ]

Hole Dimensions:

Entry Hole Dia (in): [ ] Profile Hole Dia (in): [ ]

Spall Ring Dia (in): [ ] Spall Hole depth (in): [ ]

WP Hole depth (in): [ ] WP Crater Dia (in): [ ]

Linear Hole Dia (in): [ ]

Pre-Test Observations:

Post-Test Observations:

End of Data Acquisition Sheet

Conclusion

In conclusion I was extremely successful at doing test shots and setting up a database. The database contains all pertinent information needed to run an additional series of more advanced tests. Hopefully this database will be useful in the future to other engineers in their pursuit of answers.

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THE MECHANICAL AND METALLURGICAL CHARACTERIZATION OF LIQUID PHASE SINTERED TUNGSTEN ALLOYS

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August 1997

THE MECHANICAL AND METALLURGICAL CHARACTERIZATION OF LIQUID PHASE SINTERED TUNGSTEN ALLOYS

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Abstract

Hard Target Weapon (HTW) penetrators to date have been produced from high strength low alloy steels. Although these penetrator materials have performed well against their targets, newer, more deeply buried targets require improved penetrator materials. Two tungsten alloys were evaluated for their mechanical and metallurgical properties for potential application as HTW penetrator materials. The two alloys were (1): 92.1 W, 4.97 Ni, 1.48 Co, 1.47 Fe; (2): 90.1 W, 6.1 Ni, 1.8 Co, 1.8 Fe. Tensile tests (both High Rate Instron and Split Hopkinson) confirmed a strain rate dependency, significance of tungsten particle contiguity, and indicated some differences in strength and toughness between the two materials.

THE MECHANICAL AND METALLURGICAL CHARACTERIZATION OF LIQUID PHASE SINTERED TUNGSTEN ALLOYS

Michele Viola Manuel

Introduction

Liquid Phase Sintered (LPS) tungsten alloys are candidates to replace steel in the design of hard target penetrator weapons. In LPS materials, a hard phase material is included in a matrix of weaker more ductile material. In the experiments described below, two materials differing mainly in the amount of tungsten and consequently amount of matrix material were tested in High Rate Instron and Split Hopkinson Bar machines. The chemical composition of the two alloys were as follows: (1) 92.1 W, 4.97 Ni, 1.48 Co, 1.47 Fe; (2) 90.1 W, 6.1 Ni, 1.8 Co, 1.8 Fe.

Processing

The high melting point (3410 °C) and brittle nature of tungsten requires the use of a technique known as powder metallurgy (PM). One PM method consists of first compacting fine tungsten powder and then feeding the compressed powder into a special high heat, controlled atmosphere furnace to bond the particles together. They are metallurgically fused without melting, a phenomenon called sintering.

Our specimens were processed by LPS. This means that the specimen contained additions of Co, Ni, and Fe which formed a liquid phase during sintering. The resulting material is a two phase composite consisting of tungsten grains in an alloy matrix. These alloys have high densities because of the large tungsten content. There are many advantages to using LPS. First, if you could melt tungsten, the material have limited utility for penetrator application because of its low ductility. Secondly, the Co, Ni, and Fe matrix serves as a binder for the brittle tungsten grains and redistributes stress during deformation. Furthermore, the ductile matrix allows the sintered material to have high ductilities and strengths. Lastly, since the tungsten grains are surrounded by a matrix, the contiguity (a measure of the tungsten-tungsten contact) decreases and the toughness increases.

Methodology

Twelve specimens of alloy 1 and ten specimens of alloy 2 were machined using the

dimensions shown in (Figure 1). To test these specimens, a Split Hopkinson Bar using a 464 in/in/sec strain rate and a High Rate Instron machine using a .05 in/in/sec strain rate were utilized. Twelve specimens (six using alloy 1 and six using alloy 2) were tested in the Split Hopkinson Bar. Additionally, ten specimens (six using alloy 1 and four using alloy 2) were tested on the High Rate Instron machine.

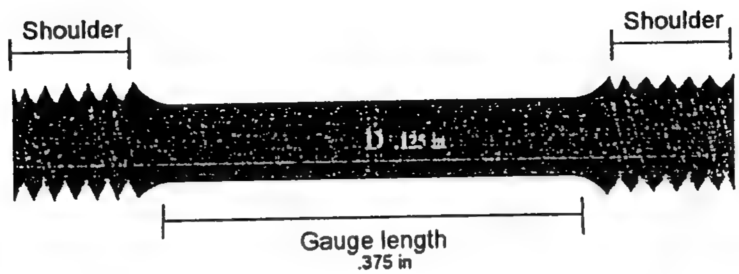


Figure 1. Typical Tensile Specimen

Split Hopkinson Bar

The Split Hopkinson Bar (Figure 2) was used for obtaining dynamic stress-strain data at room temperature. The system consists of a striker bar, incident bar, and a transmitter bar with the specimen housed between the incident and transmitter bars. The striker bar is accelerated by means of the driving force supplied from a torsion bar spring mechanism. The striker is first placed in a yoke assembly and is drawn back by means of a hydraulic piston. When the striker is in position, the pin shears and the striker is propelled impacting the incident bar. Upon impact, a compression wave is sent through the incident and transmitter bars. When the compression wave comes to the end of the transmitter bar, the wave is reflected sending a tensile wave back to the impact face.

When the tensile wave reaches the first specimen interface, a part of the wave is transmitted and a part of the wave is reflected causing the specimen to break. The relative magnitude of these waves is dependent upon the physical properties of the specimen. Because of the numerous internal reflections, the stress distribution is smoothed out. The stress can then be considered uniform along the specimen length except when the initial and final part of the pulse is rising or falling.

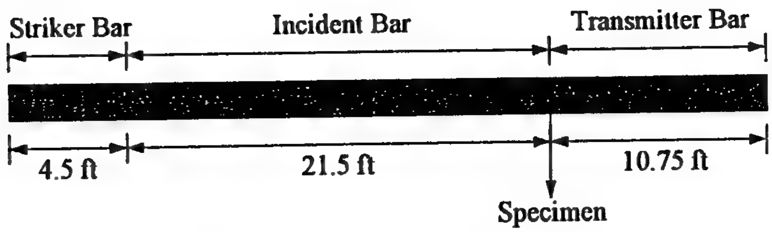


Figure 2. Split Hopkinson Bar Diagram

High Rate Instron

The High Rate Instron machine mainly consists of a load cell, which is attached to the crosshead, an actuator, the servovalve, and a hydraulic pump (Figure 3).

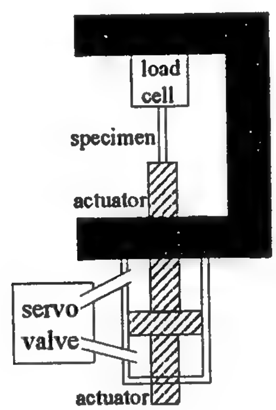


Figure 3. Cross-section of the High Rate Instron Machine

The specimen is first placed into the machine by screwing in the grips located in the load cell and actuator. Properly aligning the specimen eliminates bending loads ensuring that the specimen is subjected only to axial loads. The servovalve, which is located behind the hydraulic pump regulates the flow of fluid between the hydraulic power supply and the actuator. As valve opens, high-pressure fluid passes to the actuator. The pressure will force the actuator to move in a downward direction pulling the specimen apart giving us our tensile test. During the tensile test, the feedback transducer located within the load cell will send out information regarding stress and strain.

Results

Ten tests (six for alloy 1 and four for alloy 2) were carried out on a High Rate Instron machine at a strain rate 0.5/sec. Peak Stress, yield, and strain at failure were recorded. Twelve Split Hopkinson Bar tests (six for alloy 1 and six for alloy 2) were carried out at a strain rate of 464/sec. Thus, comparisons can be made between the alloys and between strain rates for the variables peak strain, yield, and strain at failure. Table 1 summarizes the data from the tests.

Table 1.

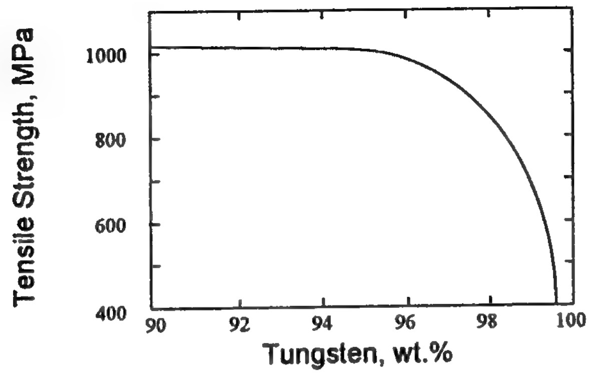
	Split Hopkinson Bar (High Strain Rate) averages		High Rate Instron (Slow Strain Rate) averages	
	Alloy 1	Alloy 2	Alloy 1	Alloy 2
Peak Stress, KSI	208.5	192.3	175.8	169
Yield, KSI	184.6	183.9	141.4	135.8
Area Under Curve	21.4	8.7	---	---
Strain, in/in/sec	0.123	0.05	0.189	0.173

Alloy 1, with 92% W, performed better than alloy 2, with 90.1%, on both Split Hopkinson Bar and High Rate Instron machine tests. Therefore, the increase in tungsten content seems to make the material stronger. The area under curve, a good indicator of ductility, was surprisingly higher in alloy 1 despite the decrease in ductile material. Our results also revealed the importance of strain rate sensitivity. It was observed that alloy 1 and alloy 2 on the Split Hopkinson Bar had an increase in toughness and strength when compared to alloy 1 and alloy 2 on the High Rate Instron machine. It was also observed that alloy 1 on the Split Hopkinson Bar had higher tests results than the other three alloys. This leads us to conclude that increased tungsten content at high strain rates yields improved performance. It should also be noted that the strain at failure is usually higher at lower strain rates because the material has time to compensate for the change in its structure; this is a typical property of ductile materials.

Discussion

"Microstructure Limitations of High Tungsten Content Heavy Alloys" by R.M. German, L.L.

Bourguignon, and B.H. Rabin investigates density, strength, and ductility variations of tungsten alloys with high tungsten concentrations (90 to 99.5 wt.% W). He theorizes that mechanical properties will decrease as the amount of tungsten content increases, however, there is reasonable strength and ductility at tungsten levels as high as 98% (Figure 4).



German, R.M., L.L Bourguignon, B.H. Rabin. "Journal of Metals." 8-19-95

Figure 4. The maximum tensile strength plotted as a function of the tungsten content for various heavy alloys.

At first glance, our results seem to contradict those stated above. Our data shows that tungsten content and tensile strength increase proportionally. However, we are working with tungsten contents in the 90 to 92% range. According to Figure 4, tungsten content in that range seem to produce results with little or no difference in tensile strength.

It was also found that alloy 1 had a lower contiguity (.55) than alloy 2 (.66). This might account for the greater toughness in alloy 1 since low contiguity signals higher toughness. Since alloy 1 was richer in tungsten and should have had the higher contiguity, this result was unexpected and points to a difference in processing.

Conclusion

In conclusion, alloy 1 performed better than alloy 2 in all tests especially at high strain rates. Since our experiments led to more questions than answers, more testing is needed using additional strain rates, contiguities, and temperatures.

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A STUDY OF CHEMICAL VAPOR DEPOSITION AND PULSE LASER DEPOSITION

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A Study of Chemical Vapor Deposition And Pulse Laser Deposition

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Abstract

The three basic topics studied over the course of this internship were building and designing circuits, programming in C code, and Raman Spectroscopy. All of these topics were studied in conjunction with Chemical Vapor Deposition equipment that continuously coated sapphire fibers and Pulse Laser Deposition that creates high temperature superconducting films. A circuit was designed which became a part of the processing equipment to make operation more convenient for the operator. Programming in C code was used to program a stepper motor for use in winding the coated fibers onto a spool at a constant angular velocity. Additionally, Raman Spectroscopy was studied as a potential sensor for use inside a coating process to yield information about the coating properties.

A Study of Chemical Vapor Deposition And Pulse Laser Deposition

Lori M. Marshall

Introduction and Discussion of Problem

During my internship I worked in a multidisciplinary office that included Materials Science, Physics, Computer Engineering, and Electrical Engineering. I worked in the Materials Process Design branch, specifically in the self-directed control group. Self directed means using intelligent sensors and algorithms to detect the material properties of interest in the thin film coating being processed, and to make adaptive control decisions as the sensed material properties begin to change (move away from the design goals). In the office I worked in there are five major thin film coating operations. Chemical Vapor Deposition (CVD) of sapphire fibers for use in interface coating for ceramic matrix composites (CMC), Molecular Beam Epitaxy for silicon class electronic and infrared devices, Pulsed Laser Deposition (PLD) of Tribological (wear) films, and Pulsed Laser Deposition of High Temperature Superconducting (HTS) films. The areas of study I focused on this summer were CVD of CMC's and PLD of HTS thin films. This is covered in more detail below.

Chemical Vapor Deposition is a widely used process for applying myriad thin film coatings to a variety of substrate materials of all different shapes. It is widely used to apply diamond wear coating's, interface coating's, and various other thin film materials. The constituents of the coating are normally ground into a fine powder and dissolved in a solvent. This mixture is heated until it vaporizes. It is then inserted via an inert carrier gas into a heated chamber. As the solvent passes through the heated chamber in the presence of oxygen, the mixture breaks down and coats the substrate. The process is extremely sensitive to the chamber temperature and the chamber pressure at the time of deposition. This particular CVD process is capable of continuously coating sapphire fiber

for use as an interface coating for Ceramic Matrix Composites [1]. The interface coating reduces the interface bond strength so that when the material fractures, the crack will turn at the coating interface rather than break the fiber. A mass spectrometer is used to detect the constituents of the gas stream. The sapphire fiber is coated when it passes through a heated chamber. The solvent is inserted with an inert carrier gas. As the fiber passes through the chamber in the presence of oxygen, it is coated with the solvent and is then wound on the spool.

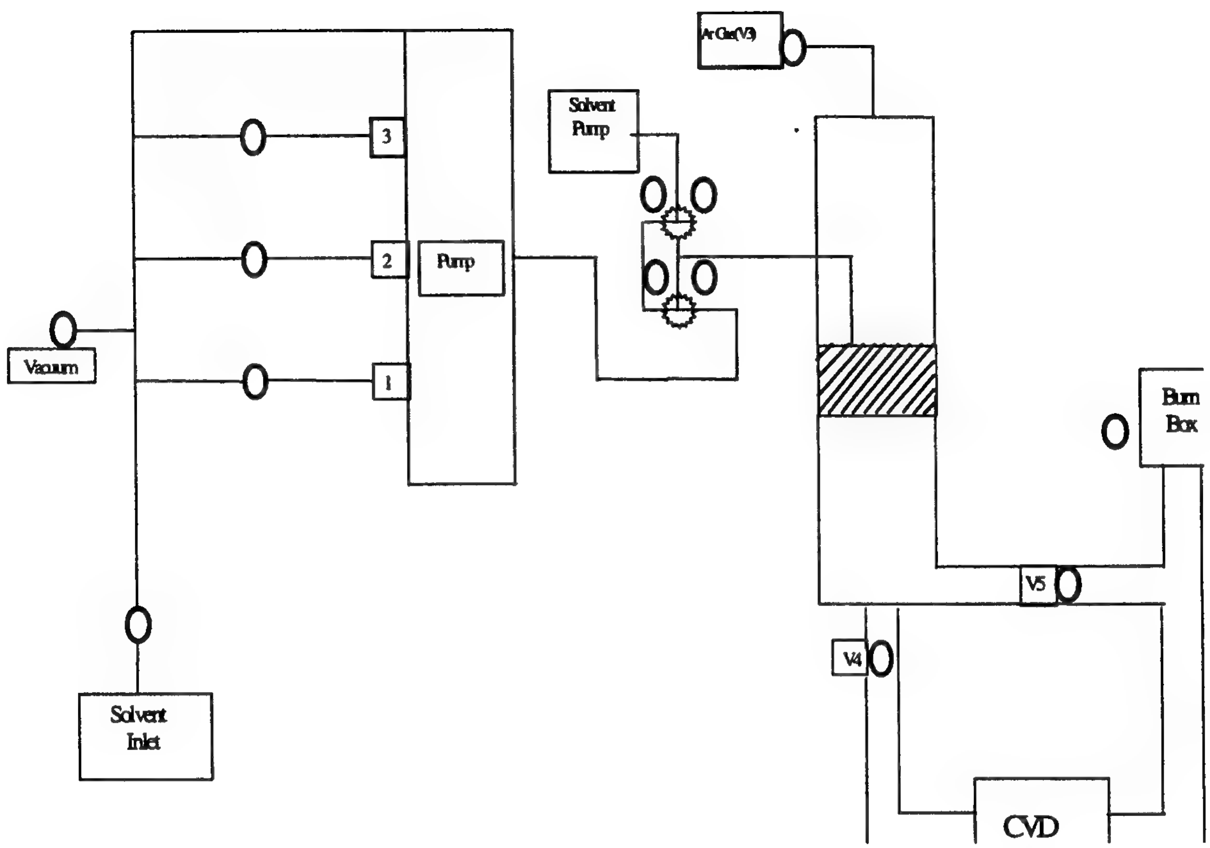
Pulsed Laser Deposition is a technique by which a powerful focused laser beam is focused upon a target of material. High energy densities cause this material to vaporize and a plume of material travels rapidly away in a direction perpendicular to the target surface. The substrate is placed in the path of the plume and the vaporized material coats the substrate.

There is much about PLD that is not yet understood. By what mechanism does the plume material adhere to the substrate? What is the optimal laser repetition rate for the best material properties? What is the optimal temperature? What pressure of oxygen is best? The questions are many and as of yet, unanswered [2]. To assist in answering these and other questions, it is necessary to find sensors that yield processing insight during the deposition process. One of the sensors that is being explored is Raman Spectroscopy.

Methodology

The system used for CVD is a complex set of PID controllers, mass flow controllers, a liquid delivery system that is capable of changing the ratio of a mixture of solvents, two vacuum pumps, a mass spectrometer to detect the constituents of the gas stream along with other miscellaneous parts that help in the coating process. The circuit that I designed as my first project this summer is used for the CVD process. The LED's are used to show when certain valves are open and when the heat box reaches a certain temperature. The circuit is useful because during the CVD process the operator does not have to check the computer program to determine what is happening during the process, the lights tell the operator.

Figure 1

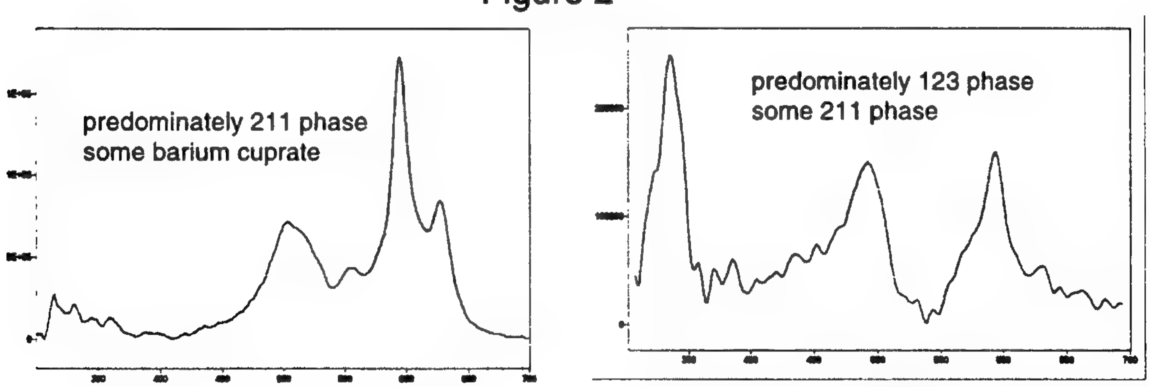


It takes a large volume of coated fiber to actually produce a part from CMC's as the fiber is coated, and since the process is continuous, the ceramic fiber is wound on a spool. The spool is wound at a constant angular velocity by a stepper motor controller. For small quantities this translates into a constant fiber velocity as the fiber is pulled through the heated vacuum chamber. However if large quantities of fibers are coated, the radius of the spool begins to increase and the fiber velocity begins to increase. To alleviate this problem, a stepper motor controller is needed in conjunction with an optical encoder to detect the speed at which the fiber is being pulled through the chamber. As the speed changes then the stepper motor controller will be adjusted accordingly. To program the motor controller, I learned about C code by writing some simple optical

design programs and through the completion of tutorials. A Motorola HC11 stepper motor controller with a QED board using the control C programming language was used in conjunction with the motor. Although this particular board used C as its programming language, LABView has some advantages for rapid programming capabilities. Programming is quicker and easier in LabView when compared to C code because LabView uses pictorial symbols instead of words to make a program.

Raman Spectroscopy is a sensor that is now being used in the PLD process for the detection of the exact nature of the process. To read a Raman spectra, a smoothing routine is preformed. I programmed a smoothing routine that averages a user-defined number of points and makes a new point using this average. This removes some of the noise from the spectra. A curve fitting routine, which was also programmed, is also necessary to identify the peaks in the spectra. The peaks show the quality of the film because all of the materials have a given peak. The peak from the spectra should be the same as the known peaks for the materials in the sample. Both of these techniques make the quality of the film easier to see. A new confocal microscope was also in use in the lab and I attended training sessions on how to use the microscope and take spectra. I was able to look at YBCO thin films and sapphire fibers and take spectra for the YBCO films, thus participating in lab operations. A good film (right) and a bad film (left) are pictured in figure two below.

Figure 2



Tc = 80K   Tc = 91K

Results

Over the course of the summer three main goals were accomplished. All of these goals centered around correct and efficient use of the Chemical Vapor Deposition equipment that is used for thin film coating of sapphire fibers and Pulse Laser Deposition of High Temperature Superconducting films. The first goal was to design and built a circuit for the Chemical Vapor Deposition equipment. The second goal was to program a stepper motor controller so that the spool could spin at a constant angular velocity that changed as the amount of fiber on the spool increased. The motor was necessary for the CVD process because CVD is a continuous process and a relatively large quantity of ceramic fiber can be produced. The third and final major goal was to work towards a better understanding of Raman spectroscopy. This was necessary for analyzing the constituents of the gas stream during the CVD process.

Preliminary results indicate that Raman Spectroscopy holds answers in finding the surface roughness of YBCO thin films [3]. Since some of the spectra are dependent on the polarization of the incoming laser light, this dependence results in a preferred crystal orientation for the coated thin film. It has been found that this orientation is strongly correlated to the surface roughness of the film [4]. Raman spectroscopy can also yield information on stoichiometry ratios of film elements, film thickness, film temperature, critical temperature and current.

Conclusion

Chemical Vapor Deposition is a complex process that is constantly being modified to make the process more efficient and more exact. Improvements and additions to the equipment are made as problems and new ideas arise. All of the changes discussed in this report were made to increase the ease and accuracy of use for the operator of the equipment. The circuit I designed makes it easier for the operator to know what is happening during each individual process because the person does not have to check the computer to see which valves are open. The stepper motor controller allows the ceramic fiber to be coiled at a constant rate by

the motor with no help from the operator during the CVD process. Part of correct and efficient operation is knowing the function of the many different complex parts of the equipment. Using new and inventive ideas to add parts is an imperative part of developing and enhancing a relatively new process so that what is already in use can be modified for the better.

Pulse Laser Deposition is a process that leaves many unanswered questions in the minds of researchers. What is known is that Raman Spectroscopy is one key to better understanding the PLD process. That knowledge will eventually help lead to the discovery of what the best conditions for PLD are and how to achieve these conditions. As time passes and more experience with Raman Spectroscopy and the PLD process is gained, some of these questions will be answered and Pulse Laser Deposition of high temperature superconducting films will become a more exact science.

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CHAIN ARMOR BALLISTIC TESTING: ESTABLISHING THE BALLISTIC LIMIT

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Final Report for:
High School Apprenticeship Program
Wright Laboratory

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EXPERIENCE AT THE AIRCRAFT SURVIVABILITY ENHANCEMENT BRANCH AT WRIGHT-PATTERSON AIR FORCE BASE

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Abstract

The project I was assigned to for the summer was a Chain Armor Ballistic Test. The objective of the test was to establish the ballistic limit of the chain armor. Before the chain armor was shot I also shot ½" and ¼" steel to establish their V_{50}. As the test engineer for the project, I supervised the fabrication of essential parts, and the preparation of the test articles. After the testing was completed, I was charged with evaluating the data and processing the data into a final report under the supervision of Mr. Alex G. Kurtz (WL/FIVSA). Following, is the Test Plan and Final Report for the project minus pictures.

CHAIN ARMOR BALLISTIC TEST PLAN

Background

Areal Density

CA#1 -- 6.9397 lbs./sq. ft.

CA#2 – 10.1727 lbs./sq. ft.

CA#3 – 10.0167 lbs./sq. ft.

Where will the test be done? -- Range 1 or Range 3

Pre-test predictions

CA#1 – the 0.30 cal AP bullet will penetrate the surface of the armor, the bullet will then be captured by the expansion of the armor

CA#2 – the 0.50 cal AP bullet will penetrate the surface of the armor, the bullet will then be captured by the expansion of the armor

CA#3 -- the 0.50 cal AP bullet will penetrate the surface of the armor, the bullet will then be captured by the expansion of the armor

Specimen preparations

Hardness test -- ???

Panels must be polished to eliminate the rough edges

Approach

Before the actual test procedures, all the test articles will have been labeled with the small armor piece labeled CA#1 and the two large armor pieces CA#2 and CA#3. The test will then be run allowing two days each for setting up the range and for test execution. The range will be setup with an overall distance of twenty feet. The test article will be at the twenty foot mark and placed perpendicular to the ground in a fixture with a ¼ inch serrated frame that will hold the panel firmly in place (Fig 2.). Four velocities will be calculated. V_1 will be calculated from the muzzle break to the panel. V_2

will calculated from the first break paper to the second break paper. V_3 will calculated from the second break paper to the panel and V_4 from the first break paper to the panel. There will be a muzzle break at the end of the muzzle. There will be break papers at the sixteen and eighteen foot marks and also one attached to the front of the panel (Fig. 1). When the break paper at sixteen feet goes off it will signal the HS camera to begin recording. A yaw card will be placed at the eighteen foot mark attached to the break paper at that location for the purpose of determining whether or not the projectile is going straight. The camera will be set to run at 1,000 FPS and will need to capture the bullet exiting the back side of the panel or the bullet being captured in the panel. Residual velocity will be calculated visually using the high speed camera and surveyor tape mounted to a board placed opposite of the camera. The board is to be placed snugly against the test fixture. A nicolet system will be used to measure the voltage impulses that will be used to calculate velocity. It will be triggered to begin at the 0.00 mark of the countdown. The camera will be placed behind the test article to observe the projectile capture and calculate the residual velocity of the projectile. Each panel will also be weighed to account for mass loss. After all four tests are complete, the tapes and data sheets will be evaluated to determine the usefulness of the armor by analyzing its resistance to penetration.

Threat

- 0.30 cal AP – Small chain
- 0.50 cal AP – Large chain

Instrumentation

- Yaw card – 18' from the end of the muzzle, 2' from the target
- Muzzle Break
- Break papers – 2' apart
    - Nicolet –
- Camera – Behind, witness dynamic deflection, calculate velocity
    - Speed – 1,000 FPS

Surveyor tape attached to board

Schedule

When – July 1997

Setup – 2 days

Test – 2 days

Data Analysis – 3-4 days

Draft Report – 1 week

Final Report – 1 week

CHAIN ARMOR BALLISTIC TEST FINAL REPORT

1.0 INTRODUCTION

1.1Background

An old armor concept with a new twist was fabricated and given to Wright Laboratory for testing. The armor concept uses compressed chain in a potted matrix. In theory, as the round hits the chain, the chain pulls on the matrix causing it to absorb energy by cracking and resisting movement of the chain. Two chain armor configurations were evaluated. The first chain armor configuration consisted of large 1¼" diameter chain and large links (labeled CA#3 and CA#4). The second configuration consisted of very small $^{9}/_{16}$" diameter chain and small links (labeled CA#1 and CA#2).

1.1 Objective

The objective of this test was to establish the V_{50} of the Chain Armor panels and to examine the ballistic limit of the chain.

2.0 APPROACH

2.1 Accomplishing the Objective

To determine the V_{50} of the Chain Armor, the first step was to find the V_{50} of ½" and ¼" steel. The steel was to be an equal representation of the Chain Armor panels. To determine the size of steel to use, we used the following equation to determine the volume of steel in the chain armor panels:

$$[(2l_1 \bullet \pi \bullet r_1^2)+((\pi \bullet D) \bullet \pi \bullet r_1^2) \bullet 264 \text{ chains}]/25 \text{ in}^2$$

The 264 chains comes from multiplying the number of chains in each row (6) times the number of rows in each layer (11) times the number of layers in the panel. Based on the above equation, the equivalent thickness of steel was 0.41in. After determining the thickness of steel to use for the large chain panels, we estimated the thickness of steel

needed for the small chain panels. We chose ¼" because there are fewer voids in the small chain.

We decided to use a mild steel. This was based on a visual inspection of the steel in which we concluded that the chain was a form of mild steel. After further inspection, we determined that the chain on the small chain panels was stainless because it did not rust and that the chain in the large chain panels was another form of mild steel because it began to rust within twenty-four hours of being cut.

After the V_{50} of the steel was found, we could call the velocity for the Chain Armor, based on the estimates from the steel. After each series was shot, a program developed by Greg Czarnecki to calculate the V_{50} of composites was used to calculate the V_{50} of the steel and Chain Armor. Since the steel and Chain Armor are not composites, the program did not give a truly correct figure, yet it did yield a rough V_{50} estimate.

We concluded after a careful visual examination of the panels, that we should use .30 cal AP rounds on the small chain links, because it was not likely that the round would slip through the chain, and armor should be tested with a threat that could penetrate it. That is why we first decided to go with the armor piercing rounds. We chose to use .50 cal AP M2 rounds on the large armor pieces, because the .30 cal rounds would probably slip through the chin without touching it.

2.2 Pretest Preparations

As mentioned above, the dimensions of the steel were based on the Chain Armor panels.. Each piece of steel and each piece of Chain Armor were then weighed to obtain their pre-test weights.

Prior to testing, a modification of a panel holder assembly from the Impact Physics fixture had to be modified to meet the needs of this test. Panels used were only 5" by 5" as compared to what previous panels have been, which were approximately 9" by 9". Toe clamps were fabricated to hold the panel in place and set bolts were installed so that the same set of toe clamps could be used for all of the panels.

Each Chain Armor panel was milled ½" in from the edges on all sides, and variably deep until as much chain as possible was exposed. This was done to grip as much of the

chain surface as was possible, so that if the round was captured in the net, the chain would not completely unravel and fly out of the fixture. Six panels each of ¼" and ½" mild steel also had to be cut for preliminary testing purposes. Each panel was also weighed using a scale that was only accurate to 1/4000 of a pound, so all pound weights are ±0.004 pounds.

2.3 Setup

It took about a day to setup Range 1 for the test. Once the fixture was in place, the gun was then positioned so that the end of the muzzle was twenty feet from the face of the target. At the end of the muzzle on the gun, there was a gun break, and there were break papers placed at the sixteen, eighteen, and twenty foot marks relative to the end of the muzzle. We used a high-speed camera that was positioned on the left side of the Impact Physics fixture and was running at 1000 FPS with the screen divided into four parts, making the actual camera speed 4000 FPS. The residual velocity was calculated using the high-speed camera. There was a grid opposite the camera with 1" by 1" boxes 1" apart in all directions that was used to see how far the round traveled in a certain amount of time (0.001 sec., 0.00075 sec., 0.0005 sec., 0.00025 sec. were the times used, depending upon which fourth(s) of the frame(s) were used). All residual velocities were visually estimated, therefore, they are only approximate figures. Lighting was provided by four 2 kW photo lights. Behind the fixture, were two witness panels were used to determine the penetration of the panels, bullet flight path and bullet orientation (pitch and yaw) after penetrating the panels.

3.0 PREDICTIONS

The pre-test predictions were that the Chain Armor would capture the round in a net that was created by the expanding chain pulling upon the matrix as the impactor penetrated the panel. We also thought that the armor would cause the round to tumble upon exiting. Our goal was to stop the bullet and establish the ballistic limit of the panels.

4.0 STEEL (½") AND LARGE CHAIN SHOTS

4.1 Panel 2-1 -- .50 cal AP M2, complete

The first shot was panel 2-1. It was a ½" mild steel panel. All "2" series panels were ½" mild steel. The panel had a velocity (measured from Break Paper 2 to the target) of 1526 fps. This panel was shot with a .50 cal AP M2 round that had an impactor weight of 692.6 grains. The pre-test weight of the panel was 3.449 pounds and the post-test weight was 3.447 pounds. This left a difference of 0.002 pounds. The panel was penetrated by the round, but a residual velocity was not obtained due to the malfunctioning of the Kodak camera.

4.2 Panel 2-2 -- .50 cal AP M2, complete

Panel 2-2 was next to be shot. The pre-test weight of the panel was 3.446 pounds and the post-test weight was 3.445 pounds. The difference was 0.001 pounds. This panel was penetrated by the round, which weighed 692.6 grains. The velocity of the round was calculated at 1284 fps. The panel was penetrated by the round and the residual velocity of the round was 500 fps We ran the figures from this shot through Greg Czarnecki's program to determine the V_{50} of the panel. The results from the program told us that the V_{50} of ½" mild steel was 1182 fps.

4.3 Panel 2-3 -- .50 cal AP M2, partial

Panel 2-3 was the first non-penetrating shot. The velocity of the round was 890 fps. The pre-test weight of the panel was 3.445 pounds and the post-test weight of the panel was 3.444 pounds. There was a pre-test and post-test weight difference of 0.001 pounds. The impactor weight of the round was 691.9 grains.

4.4 Panel 2-4 -- .50 cal AP M2, partial

Panel 2-4 was very near the ballistic limit. The panel was only partially penetrated with a small hole on the back side where the penetrator was not able to bore completely through the panel. The tip of the penetrator stuck into the plate and it shattered the round.

The panel had a pre-test weight of 3.444 pounds and a post-test weight of the same. The velocity of the round was 1020 fps. The weight of the penetrator was 693.7 grains.

4.5 Panel 2-5 -- .50 cal AP M2, partial

Panel 2-5 was another partial penetration shot. The shot had a velocity of 1060 fps. The tip of the penetrator was stuck into the panel, as the rest of the round was shattered and fell off. The pre-test weight of the panel was 3.457 pounds and the post-test weight was 3.469 pounds with the tip of the round still stuck into the panel. The impactor weight of the round was 691.7 grains. Based on the results of panel 2-4, we should have called the shot a higher velocity so that we could have another penetration shot.

4.6 Panel 2-6 -- .50 cal AP M2, partial

Panel 2-6 was the last panel of ½" mild steel to be shot before the Large Chain Armor panels were shot. The panel had a pre-test weight of 3.463 pounds and a post-test weight of 3.478 pounds with the tip of the round still stuck into the panel. The round velocity was 1051 fps. There was no residual velocity since the round stopped in the panel. The impactor mass was 696.2 grains.

4.7 Panel CA#3 -- .50 cal AP M2, complete

Panel CA#3 was the first Chain Armor panel to be shot. Before the shot was called we ran the figures of the ½" mild steel through a V_{50} program developed by Greg Czarnecki to try to obtain a velocity close to the ballistic limit of the Chain Armor. Based on the program's calculations, we estimated that the V_{50} was about 1150 fps and called the shot at 1150 fps. The round completely penetrated the Chain Armor in the first shot. The panel had a pre-test weight of 1.643 pounds and a post-test weight of 1.520 pounds. The velocity was 1105 fps. The residual velocity was 500 fps and the impactor mass was 693.6 grains. When we looked back on the camera after the shot, we saw a lot of flying debris bouncing off of the front of the panel and also flying out of the back. We could also see chains flopping around after they had become dislodged from the rest of the panel. When we looked at the panel after it had been shot, we noticed that there was a

piece of chain missing and that one of the links had been bent perpendicular to the panel. It was also quite noticeable that the welds on the links were a weak point of the armor because most of the time, where we noticed broken links, it was at the weld point. Approximately 30% to 40% of the panel was undamaged, based on visual inspection.

4.8 Panel CA#4 -- .50 cal AP M2, complete

The second Chain Armor panel, panel CA#4 was calculated to have a V_{50} of 812 fps based on the results of the previous shot's data when entered into Greg Czarnecki's V_{50} program. The impactor mass was 697.9 grains and the pre-test panel weight was 1.689 pounds. The post-test panel weight was 1.621 pounds. The velocity of the shot was 774 fps. The residual velocity was 170 fps. Once again, there was a complete penetration of the panel. The damage to this shot was more severe than that of the previous shot. There was a considerable amount of twisted metal in the center where the bullet went through. Two rows of chain were also dislodged from the matrix and were not held in by the toe clamps as they were supposed to have been. Approximately 20% to 30% of the panel was left undamaged, based on a visual inspection of the panel.

4.9 Panel 2-7 -- .50 cal AP M2

The RSO accidentally put the wrong kind of powder in the shell. He used .30 cal powder instead of .50 cal. The shot was supposed to be right around 1150 fps, but the shot had a velocity of 1751 fps and the residual velocity was an overwhelming 1200 fps. The pre-test weight was 3.525 pounds and the post-test weight was 3.526 pounds. The impactor mass was 692.4 grains. The shot melted the steel as it penetrated and left a considerable amount of lead on the face of the panel. The shot could have still been cleaner at a higher velocity, because the panel still dimpled at this velocity.

4.10 Panel 2-8 -- .50 cal AP M2, partial

The velocity of the shot was 1101 fps. The pre-test weight was 3.530 pounds and the post-test weight was 3.532 pounds. The shot was a partial penetration and the impactor mass was 691.8 grains.

4.11 Panel 2-9 -- .50 cal AP M2, partial

Panel 2-9 was also a partial penetration. The velocity of the shot was 1160 fps. The pre-test panel weight was 3.525 pounds and the post-test panel weight was 3.527 pounds. The impactor mass was 696.7 grains.

4.12 Panel 2-10 -- .50 cal AP M2, partial

Panel 2-10 had the round stick in the plate. The velocity of the shot was 1240 fps. This was the first time we managed to get a round to stick in 1/2" mild steel without the round shattering. This also meant that we were getting closer to the V_{50}. The pre-test panel weight was 3.521 fps and the post-test panel weight was 3.598 pounds with the round still in the panel. The impactor mass was 693.5 grains.

4.13 Panel 2-11 -- .50 cal AP M2, partial

The round also stuck into the plate of panel 2-11. The velocity was 1281 fps. The impactor mass was 693.7 grains. The pre-test panel weight was 3.523 and the post-test panel weight was 3.579 pounds also with the round still in the plate.

4.14 Panel 2-12 -- .50 cal AP M2, partial

The round shot at Panel 2-12 also stayed in the panel without shattering. The panel had a pre-test weight of 3.523 pounds and a post-test weights of 3.579 pounds with the round still in the panel. The velocity was 1240 fps. There was no residual velocity as the round did not completely penetrate the panel. The impactor mass was 691.9 grains.

4.15 Panel 2-13 -- .50 cal AP M2, complete

Panel 2-13 was completely penetrated by the round. The shot velocity was 1393 fps. The residual velocity of the round was 540 fps. The panel had a pre-test and post-test weight of 3.503 pounds. The impactor mass was 690.8 grains.

4.16 Panel 2-14 -- .50 cal AP M2, partial

Panel 2-14 was actually shot before panel 2-13. The shot had a velocity 1270 fps and the residual velocity was 0. The round stuck into the plate once again. The impactor mass was 691.9 grains. The pre-test weight was 3.523 pounds and the post-test weight was 3.579 pounds, again with the round still stuck into the panel.

5.0 STEEL (¼") AND SMALL CHAIN SHOTS

5.1 Panel 4-1 – ¼" mild steel -- .30 cal AP, partial

The first piece of 1/4" steel to be shot was panel 4-1. The panel had a pre-test weight of 1.703 pounds and a post-test weight of 1.702 pounds. The shot partially penetrated the panel. The shot velocity was 1070 fps. The impactor mass was 162 grains.

5.2 Panel 4-2 – ¼" mild steel -- .30 cal AP, complete

Panel 4-2 was completely penetrated. The mean velocity of the shot was 1440 fps and the panel velocity was 1422 fps. The residual velocity was unknown due to problems with the camera. The impactor mass was 162.4 grains and the pre-test and post-test weights were both 1.708 pounds.

5.3 Panel 4-3 – ¼" mild steel -- .30 cal AP, complete

Panel 4-3 was another penetration shot. The velocity of the round was 1196 fps and the shot had a residual velocity of 385 fps. The pre-test weight was 1.672 pounds and the post-test weight was 1.680 pounds. The impactor mass was 163.2 grains.

5.4 Panel 4-4 – ¼" mild steel -- .30 cal AP, complete

Panel 4-4 was also a penetration shot. Both the pre-test and post-test weights were 1.701 pounds and the impactor mass was 162.5 grains. The shot velocity was 1224 fps. The shot had a residual velocity of 290 fps.

5.5 Panel 4-5 – ¼: mild steel -- .30 cal AP, partial

Panel 4-5 was the 1/4" mild steel shots. The round actually stuck in this panel without shattering and it was less than half of a centimeter from penetrating completely. The velocity of the shot was 1158 fps. The impactor mass was 162.2 grains. The pre-test panel weight was 1.705 pounds and the post-test panel weight was 1.715 pounds with the entire penetrator minus the copper jacket still in the panel.

5.6 Panel CA#1—Small Chain Armor -- .30 cal AP, complete

Panel CA#1 was shot after 4-5. The panel had a pre-test weight of 1.181 pounds and a post-test weight of 1.166 pounds. The round went all the way through the panel and it shattered the matrix holding the panel together around the entry hole and the area surrounding the rows of chain that separated from the surface of the panel. After impact, the bullet fell sharply to the left and downward. The shot had a velocity of 1129 fps. The residual velocity was 50 fps. By watching the high-speed camera played back after the shot, we noticed a significant amount of flying debris (mostly the matrix) ejected from both the front and rear of the panel. The chains flopping against the rear of the panel was quite noticeable in the video once the chain was freed of the matrix. The impactor mass was 162 grains. Based on a visual inspection of the panel after the shot, approximately 65% to 75% of the panel was left undamaged by the round.

5.8 CA#2 – Small Chain Armor -- .30 cal AP, complete

CA#2 was accidentally shot at too high of a velocity. The shot velocity was 1088 fps. The residual velocity on this shot was also higher than the other -- 333 fps. The round tumbled after it was ejected from the panel. It went high and right and ended up wedged into the second witness panel at the end of the range approximately 6 feet from the back of the panel. The impactor mass was 161.6 grains. Approximately 75% to 80% of the panel was left undamaged based on a visual inspection of the panel after the shot.

6.0 DISCUSSION OF RESULTS AND RECOMMENDATIONS

6.1 Large Chain Armor

After going back and looking at the panels and at the test data, the Large Chain Armor panels have too many voids to be successful. Panel CA#3 had a nice, clean penetration hole in comparison to CA#4. The chain did absorb enough of the energy so that the matrix stayed together enough to hold the panel together. The panel requires a matrix that absorbs more energy per unit volume and shattering. There also needs to be less unit volume of the current matrix and a higher percentage of metal per unit armor volume. One thing I noticed in the construction of the chain was that the chains were only linked together in one direction on each plane. If all of the rows on each plane were linked together, the whole plane would act to absorb energy, rather than just the single rows; hence, a 3-D chain weave would be more efficient in absorbing the ballistic impact. There should also be more uniformity to the structure. Even within the same panel, the layers were not even, making the tests vary greatly between one panel and the other.

6.2 Small Chain Armor

The Small Chain Armor panels were damaged much less than the Large Chain Armor. The entrance holes were nice and clean, and the exit holes were less fractured in the area surrounding them. I feel that this had a lot to do with the fact that the small chain could expand more than the large chain. Few of the links on the Small Chain Armor panels were damaged or broken, while there were many broken or damaged links on the Large Chain Panels. I believe that this is due to the tightness of the chain links.

6.3 Comparison to Ceramic Panels

When ceramic panels shot at higher velocities, using tungsten steel balls as a projectile, the panels absorb a great deal of energy by shattering enough to absorb the energy, yet are still able to hold the panel together. In reality, the chain armor panels need to shatter more, yet be able to withstand impacts at higher velocities than it can withstand now. The ultimate goal is to stop the round. Using natural rubber or ceramic as a matrix in the panels would absorb more energy.

CHAIN ARMOR TESTS

PANEL	MEAN VEL.†	BP1 to BP2†	BP1 to TARGET†	PANEL VEL.†	RES. VEL.†	ROUND WT.‡	PANEL WT.•	AFTER•	DELTA•
2-1	1562	1543	1535	1526	N/A	692.6	3.449	3.447	-0.002
2-2	1353	1345	1315	1284	333	692.6	3.446	3.445	-0.001
2-3	935	929	919	890	0	691.9	3.445	3.444	-0.001
2-4	1039	1028	1024	1020	0	693.7	3.444	3.444	0
2-5	1085	1078	1069	1060	0	691.7	3.457	3.469*	0.012
2-6	1078	1073	1062	1051	0	696.2	3.463	3.478*	0.015
CA#3	1136	1127	1115	1105	250	693.6	1.643	1.52	-0.123
CA#4	793	787	780	774	333	697.9	1.689	1.621	-0.068
4-1	1085	1078	1074	1070	0	162	1.703	1.702	-0.001
4-2	1440	1464	1443	1422	N/A	162.4	1.708	1.708	0
4-3	1215	1236	1216	1196	385	163.2	1.672	1.68§	0.008
4-4	1240	1265	1244	1224	290	162.5	1.701	1.701	0
4-5	1172	1190	1173	1158	0	162.2	1.705	1.715*	0.01
CA#1	1145	1166	1148	1129	50	162	1.181	1.116	-0.015
CA#2	1100	1122	1105	1085	333	161.6	1.153	1.144	-0.009
2-7	1810	1830	1788	1751	1200	692.4	3.525	3.526	0.001
2-8	1127	1117	1109	1101	0	691.8	3.53	3.532	0.002
2-9	1190	1184	1171	1160	0	696.7	3.525	3.527	0.002
2-10	1280	1298	1268	1240	0	693.5	3.521	3.598*	0.077
2-11	1320	1317	1299	1281	0	693.7	3.523	3.579*	0.056
2-12	1310	1303	1270	1240	0	691.9	3.523	3.579*	0.056
2-13	1433	1416	1404	1393	540	690.8	3.503	3.503	0
2-14	1347	1333	1319	1305	0	691.1	3.505	3.562*	0.057

†velocities measured in feet per second (fps)(f/s)

‡impactor mass measured in grains (1 grain is equal to 1/7000 pounds)

•Panel weights, panel post-weights, and delta are measured in pounds to the nearest 1/1000 of a pound. The scale is accurate to 4/1000 of a pound. All weights are recorded as the scale read at the time that they were weighed.

*A fragment of the bullet was embedded in the panel and was included with the panel's post-impact weight. Actual post-impact weight can be extrapolated from the post-impact weight of the other panels. Other panels that increased in weight after the shot can be attributed to the resolution of the scale and/or some of the panels had lead from the bullet casing melted on to the edge of the hole where the impact occurred

§Gain in mass is unaccounted for and cannot be determined.

Figure 6-1: Test Data

A SUMMER AT WRIGHT PATTERSON AIR FORCE BASE

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Final Report for:
High School Apprenticeship Program

Sponsored by:
Air Force Office of Scientific Research
Wright Patterson Air Force Base, OH

December 1997

A SUMMER AT WRIGHT PATTERSON AIR FORCE BASE

Deborah S. Mills
Ohio University

Abstract

The apprenticeship through Wright Patterson Air Force Base for the summer of 1997, proved to be a very informative and eye-opening experience. As a temporary employee of the base, an office and position was assigned. Given with the instructions to "do whatever you want to accomplish this summer," many ideas were investigated until a more permanent position was found. Web page design, flight dynamics, wing design, and computer technician were among the subjects explored during the summer.

A SUMMER AT WRIGHT PATTERSON AIR FORCE BASE

Deborah S. Mills

Introduction

At Wright State University (District Science Day, Dayton, OH) WPAFB awarded several apprenticeship programs to select superior rated projects. Such an acknowledgement was awarded to my project to work at WP for the summer of 1997. Unfortunately, there was no research or experimentation to be done or assigned to be completed for the summer. So, after being assigned a desk, it was up to me to decide where and what "I wanted to do for the summer." Web page design, using html, seemed like the most logical step to take at the time. Later I transferred to the flight dynamics and wing design department. Again though, nothing was found for someone of my background and knowledge to be completed. So after helping with some more web design for their department, I later transferred down stairs to the computer labs. This is where I spent the remainder of the summer. I became an aid for the other computer technicians. With much previous knowledge of computers, I was able to accommodate this department best. With much experimentation on dismantling and working with hardware, I soon became a welcome asset to the department, completing minor, but important tasks.

Methodology

When first arriving at the base, web page design quickly took my interest. After a few days of surfing and practicing, a sample html document was crudely made. Although very proud of this first attempt, much more practice was done before attempting anything more permanent. By the next week, a task was put forth, along with a fellow employee from another program, to design the department's web page. While this department already had a crude page in use, the job was to add more information about the office and more embellishments to each topic. This would be an easy task for the experienced html user, but proved to be a very ambitious one for two newly self-taught users. Under the direction of Mr. Pound, a co-worker and I spent the next two weeks designing and changing their current pages. The total task ended in a multi-linking and graphic intensive site that totaled over seventy-eight carefully designed pages. Each one was made with graphics we designed in paint programs and included links to anywhere on base. The total project left both of us looking for other opportunities. So I transferred to the flight

dynamics department, where I found very quickly how little knowledge I had of aerodynamics. My days there (which were very few) consisted mainly of reading and learning not only wing design, but material design as well. There was no job for me there and my lack of knowledge in the field made me more of a nuisance than a help. They did, however, need a better web page with more up-to-date information on current projects and designs. However, because theirs was all prepared through a Unix system, for which I have little knowledge, I was of little help. So once again I transferred, this time downstairs to the computer department. There I worked with computer hardware that was to be discarded. After two weeks of orientation, I worked along with two other employees with technical backgrounds. I eventually got a clientele for myself and helped with the others to do minor jobs. By building servers, maintaining computers, and helping with minor tech problems, I soon had a job I truly enjoyed!

Results

Although no research was done, and no experiments were completed, several things were gained from the experience. In the first two weeks I learned html without an editor and was able to design my own web page. This has turned out to be a very valuable skill, especially in college, where I now maintain my own web page. Although I now use an editor, the theory of html is the key in doing any type of web design. I am now able to design my own pages, complete with graphics (personally designed), links (external and internal), and of course all sorts of other embellishments. It has proven to be a very important resource to have. I also learned about wings and the history and design of planes in general. It was very unfortunate that I did not have a backing in this prior to the internship, but aeronautics has never been a studied subject. A main area of knowledge that I gained here, was just the use of vocabulary. Many of the common terms like fuselage and transonic cruise are not your average vocabulary for a high school student. A lot of focus on structural design of materials in wings was very important. As time grew short, I transferred again to the tech department. I learned the most here with hardware and software. Not only did I learn how to build a computer, but how to maintain it as well. Now the common problems that an average user might encounter are not common for me. I can do anything from build a server to clock up a computer. Of course I am not completely proficient in everything, but for a person my age, I am able to get around quite nicely. These skills have helped me, not only in my computer science at college, but to land a tech job at school. With the prior knowledge I acquired at Wright Patt, I was able to excel in the computer courses and be head computer lab assistant this year for my course. Overall, this has all helped me in my college career as well as my everyday computing.

Conclusion

To conclude, this was a very good experience for the average high school student. Although there was no research to be done, or experiment to be completed, I feel that I still accomplished many things and used this experience to my advantage. While in several of the different departments, traveling not only off the base, but on base as well, was a very common occurrence. I was able to enter many of the buildings that the common public never would have seen and was able to perform useful functions in the process. This was a rare opportunity and I would dearly like to thank everyone who made it possible! The contacts that I made, and the people I met were outstanding and incomparable. I learned many valuable things, not limited to the departments I visited, but also about life in general. It was the true five in the morning to six at night job. I was happy to stay over and made many really great friends with whom I still stay in contact. I expanded my initial knowledge many times over in every aspect. I cannot think of any area of my life that was not changed as a result of this experience.

Studies in Computational Chemistry and Biomimetics

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Final Report for:
High School Apprentice Program
Wright Laboratories, Materials Directorate

Sponsored by:
Air Force Office of Scientific Research
Bolling Air Force Base, DC

and

Wright Laboratory

August 1997

Studies in Computational Chemistry and Biomimetics

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Abstract

The main focus of my studies was to study mechanical properties of polymers. I calculated the mechanical properties by use of the semi-empirical program MOPAC, and have also had to learn UNIX, Cerius2, Quanta, Biosym, ChemDraw and Chem 3D. Cerius2 was used in the construction of the molecule and in setting up the MOPAC process. MOPAC93 was mainly used in the computational investigation to determine the heat of formation with straining the molecule and evaluate the modulus. The other focus of my studies was based on a snake project. Snakes have so-called "pits" near the front of their mouth. These pits and other organs of the body are being used to determine how snakes use their infrared sight and how this understanding can mimic devices of interest.

Studies in Computational Chemistry and Biomimetics

Ryan M. Moore

Introduction & Background

Mechanical Properties is a computational instrument for calculating the mechanical properties of materials. The purpose of computing the mechanical properties of molecules is to evaluate their potential as structural materials. Through the use of various programs within the network of computers at the base, this is accomplished.

Calculations, in particular molecular mechanics calculations and molecular orbital calculations, play a multiple role in modern-day computational chemistry. Traditionally, they have served to supply information about the structures, relative stabilities and other properties of isolated molecules. Because of their inherent simplicity, molecular mechanics calculations on complex molecules may even be performed on personal computers, and probably because of this, have spread widely throughout the chemical community.

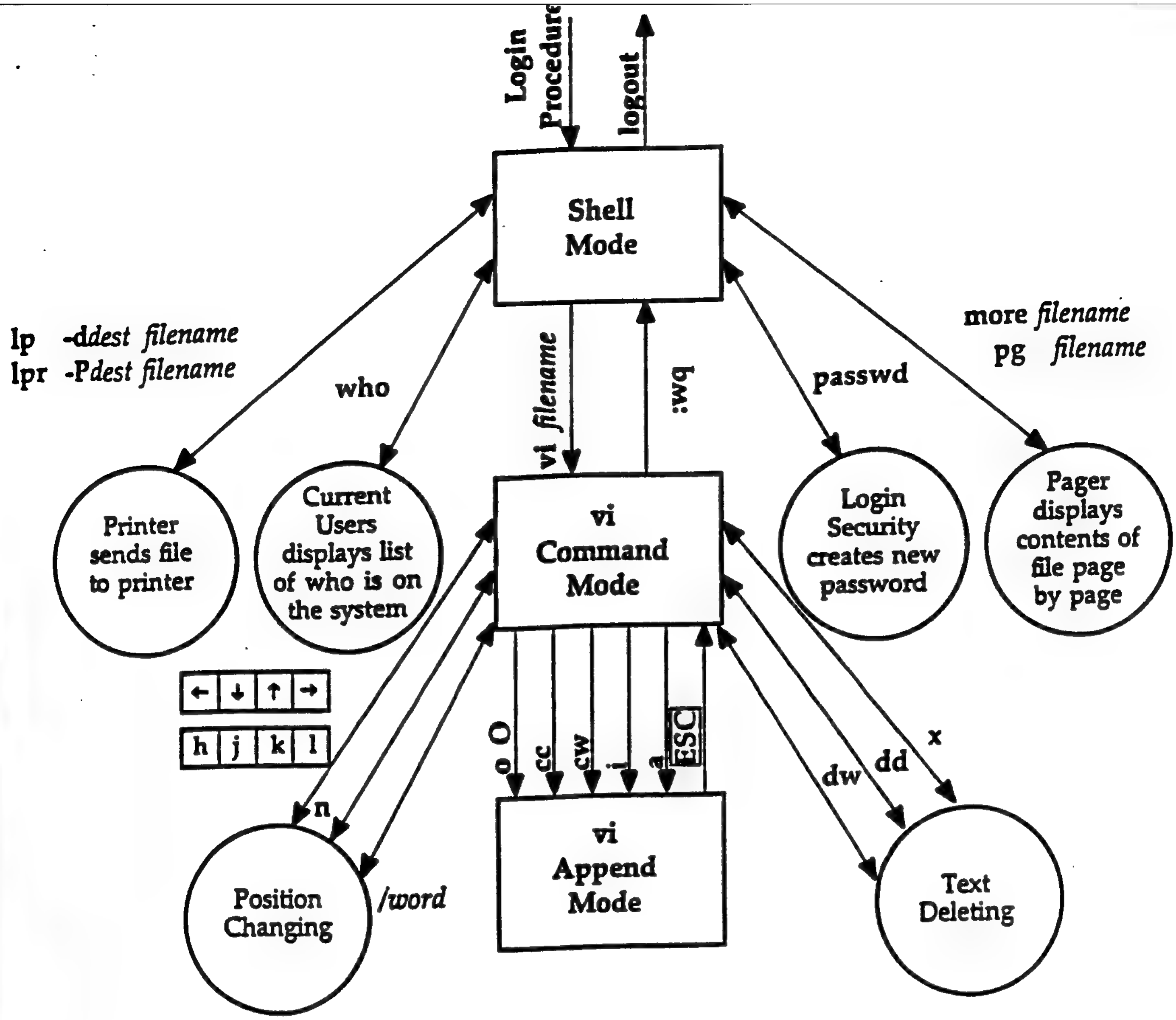
Computational modeling of materials at the molecular and atomic scale is now established as an important method in materials research. Modern technology makes possible the simulation and prediction of molecular structures, their behavior, and their performance in laboratory tests and analytic procedures. Thus, materials modeling can significantly reduce the amount of experimental work required and guide creative solutions -- resulting in a shorter product

development cycle.

An experiment was also conducted on Ball and Burmese pythons. This involved observing "pits" near the mouth and nostrils of these elusive snakes. These pits are used by the snake to determine infrared radiation emitted from various living things. These snakes were grown and raised for many weeks in a sanitary and humid environment. They were usually only fed dead mice once a week, while their water was changed about once a day. The Ball pythons were usually very shy while the Burmese pythons were moderately aggressive.

Methodology

UNIX is largely a character oriented program that has proven to be a suitable platform on which to build many useful and highly portable research and commercial applications. It was invented in the late 1960's for a small computer with a 64K-byte address space. Today it is spreading to more and more systems from PC's to Cray Supercomputers. Since UNIX is written in a mostly machine independent way (in the high level language "C"), therefore it is more easily moved to new machines. One can also use UNIX from any kind of terminal and over dial-up phone lines or computer network connections. UNIX comes with a valuable set of connectable tools which, even if they do not directly address the problem at hand, can be conveniently composed into a solution. The next page shows the conceptual map of editing with the vi editor in UNIX.

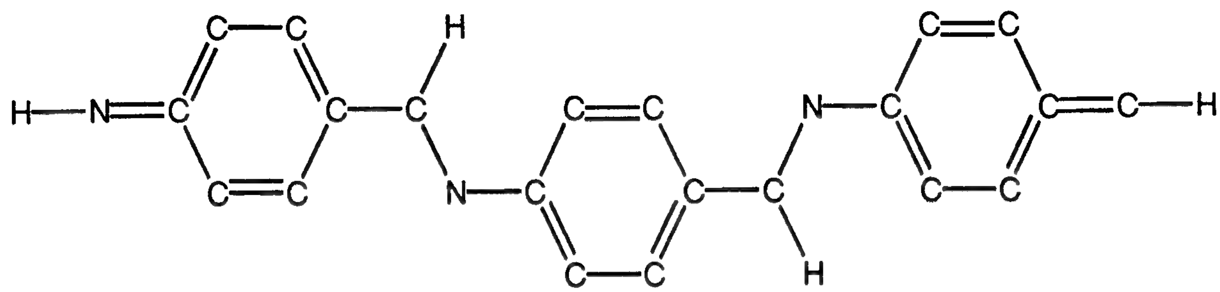


The above diagram shows the conceptual map of the vi editor in UNIX.

ChemDraw is a very useful tool when building a molecule from scratch. One can build anything from a cyanide to a complex porphyrin. Once one is finished sketching their molecule with ChemDraw, you can advance to the more powerful Chem 3D. This program has lots of features that let the user rotate the molecule 360 degrees in any given direction, minimize the energy of the molecule or even compute the mechanical properties of the molecule.

By using UNIX, one can easily access Cerius2, a useful tool in visualizing a molecule and manipulating it in various ways. This program is created and maintained to lead the world in modeling technology for materials research applications. Each CERIUS instrument uses computational methods to predict properties or assist structural analysis using molecular or atomic scale models. Applications are to polymers, ceramics, metals/alloys, zeolites, catalysts, semiconductors, organometallic and molecular materials. CERIUS instruments are composed of combinations of Builder modules, such as CERIUS Crystals and CERIUS Polymers, and Computation modules, such as CERIUS HRTEM and CERIUS Rietveld. Each CERIUS instrument uses computational methods to predict properties or assist structural analysis using molecular or atomic scale models.

PAM was first constructed in ChemDraw, then was minimized in Chem 3D and finally manipulated to perfection in Cerius2. Here is a 2-D sketch of the molecule itself:



Dummy atoms were added to both ends of the molecule and a translation vector was also added to one of the ends. Geometry optimization was then run on the molecule. After the calculation was finished, it was checked to make sure that it had retained its original structure and that everything seemed in order. It was then edited in the VI editor (UNIX).

The prediction of mechanical properties of polymer chains has centered so far primarily on the use of empirical potential energy functions, also for poly((p-phenylene terephthalamide) (PPTA or Kevlar®). However, calculations of the mechanical response based on empirical potentials are limited since a classical force-field is applied, which is dependent on a particular parametrization scheme, and also inasmuch as not all possible deformation modes are taken into account. Indeed, a theoretical evaluation of chain moduli and electronic properties of polymers by a molecular orbital approach constitutes a continuing effort of our laboratory. Analysis of molecular structures on the application of axial strain, e.g., for rigid-rod polymers (PBI, PBZT, PBO), PE, highly conjugated structures (PPP and C60), and biopolymers, offered insight into deformation processes at the molecular level and their strain-dependent stiffness behavior. The

predicted stiffness compared well, for example, with macroscopic stress-strain curves for rigid-rod fibers. The theoretical moduli were however shown to be higher than those determined experimentally, which may be rationalized on the basis of the observation that solid material properties are limited by imperfections and morphology (e.g., multiple phases and microfibril orientation distribution), while these calculations are performed on models of idealized single polymer chains. Also, the semi-empirical method systematically overpredicts bond stiffness, as was confirmed by a comparison with ab initio results for polyethylene.

Computational Details. The polymer calculations we performed apply the semi-empirical Neglect of Differential Overlap approximation at the modified level AM1 (Austin Model 1), and within this approach the so-called 'cluster method', that characterizes a polymer by a translation vector Tv, was employed. In this approximation, a segment of a polymer is defined by a number of repeat units, with periodic boundary conditions applied to describe different unit cells, resulting in a calculated magnitude that bounds the ultimate modulus. The advantage of this technique is that end effects are eliminated. The modulus and strain-dependent frequency calculations for a polymer cluster model then follow a two-stage protocol. Specifically, after an equilibrium geometry of the cluster is calculated, the translation vector Tv is incrementally increased or decreased, representing molecular tensile or compressive strain, and the geometry of the cluster under this constraint optimized. The dependence of the heat of formation on molecular strain can thus be established. The stiffness of the polymer chain is given by the second derivative of the heat of formation vs. strain relationship, used to evaluate a single polymer chain modulus as

described briefly by Eqs. (1.1)-(1.3) below. For each of these strained geometries a normal mode analysis is carried out in order to determine the strain-dependence of the system's characteristic frequencies.

The elastic modulus E for a polymer is given by:

$$E = \frac{\sigma}{\varepsilon} = \left(F \big/ A_{eq} \right) \Big/ \left(\Delta L \big/ L_{eq} \right) = KL_{eq} \big/ A_{eq} \qquad (1.1)$$

where σ is the stress (force/area), ε is the strain (fractional change in cluster length ΔL), K the force constant ($F/\Delta L$) and L_{eq} the equilibrium length of the polymer as obtained from the calculation. The force constant is derived [12] from the dependence of the change in heat of formation ΔH_{ff} on ΔL:

$$\Delta H_{ff} = a_1(\Delta L)^3 + a_2(\Delta L)^2 + a_3(\Delta L) + a_4 \qquad (1.2)$$

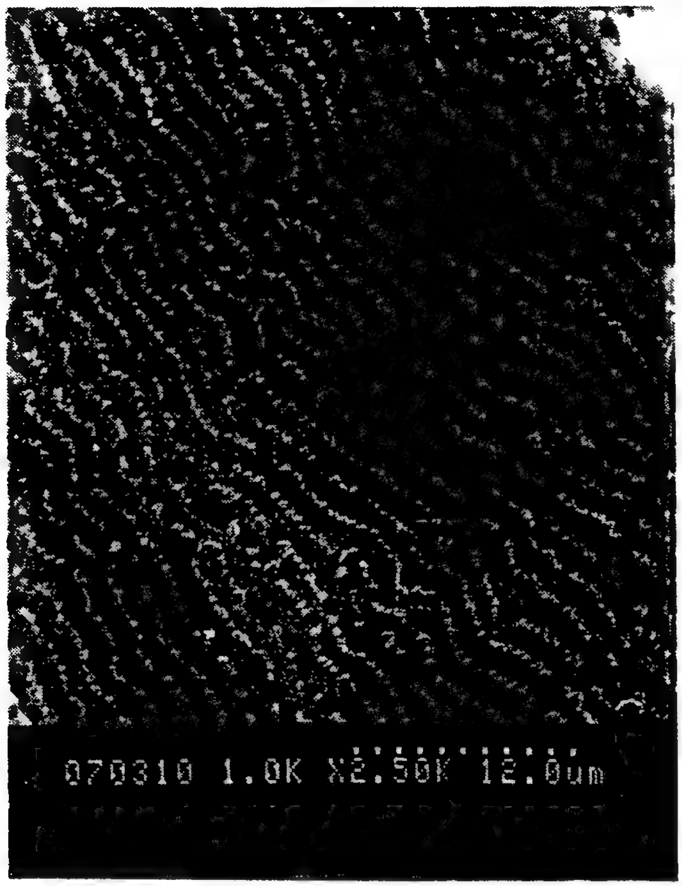
where $K = 2a_2$ at equilibrium at 0 K. The cross sectional area A_{eq} is obtained from X-ray diffraction or the density d (grams/cm^3) by:

$$d = m \big/ V = m \big/ A_{eq}L_{eq} = nM_w \big/ A_{eq}L_{eq} \qquad (1.3)$$

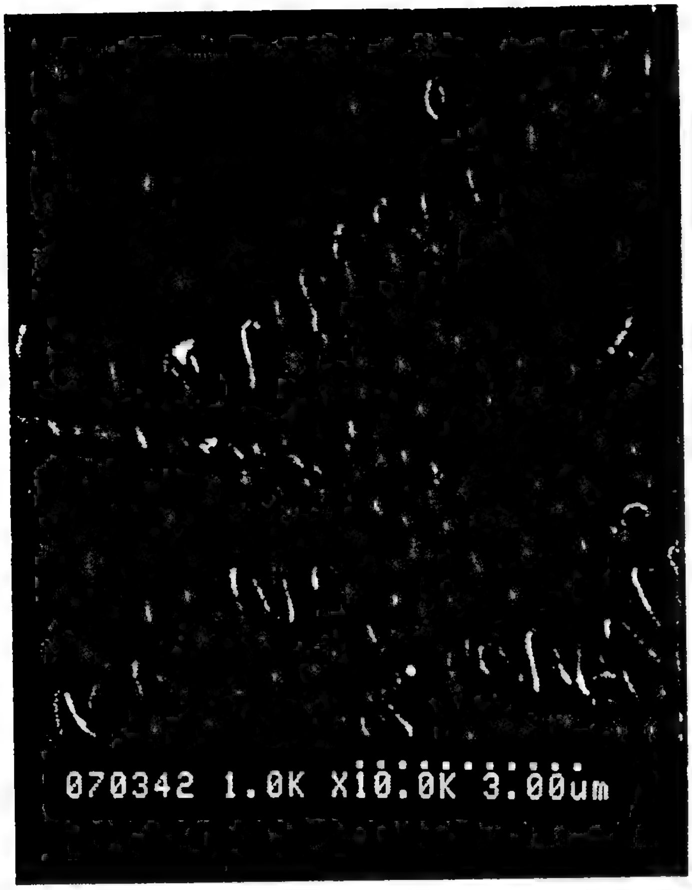
so that $A_{eq} = M_w / dN_A L_{eq}$; M_w is the molecular weight, n number of moles, V volume, and N_A Avogadro's number. The force constant can be alternatively derived by numerical differentiation, but the values obtained by either method are within the fitting procedure error.

The original length of 19.032 Angstroms was multiplied by 15% to get 21.887 Angstroms. In the VI editor, the original length of was then fixed and the last line was edited to include the lengths 19.0, 19.1, 19.2 ... 21.9 Angstroms. Every tenth Angstrom, from 19.0 to 21.9, was run through MOPAC and each geometry optimization was calculated.

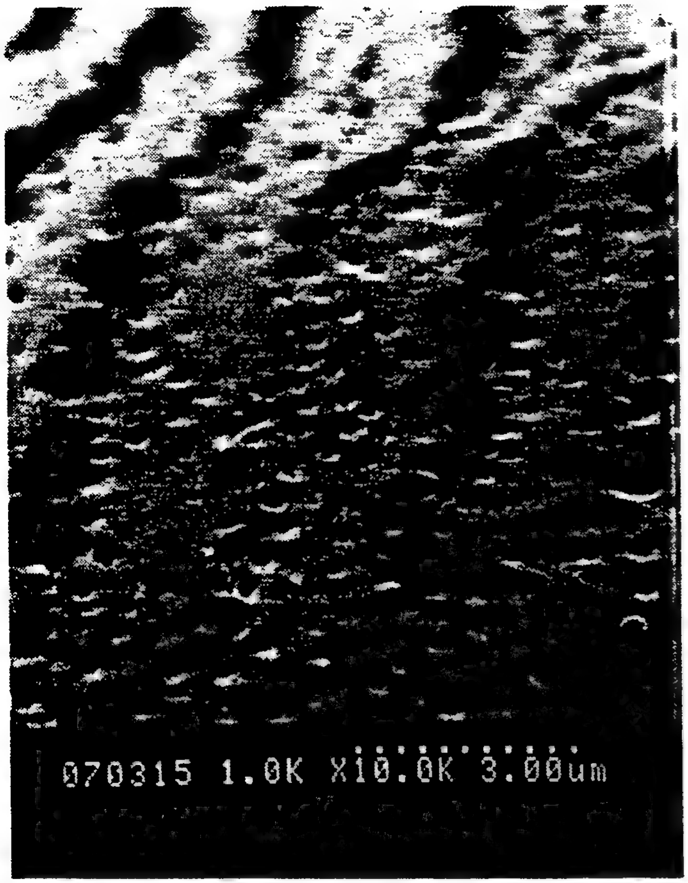
In the snake project, three of the animals lost their lives to research. Two heads off Ball pythons and one head off a Burmese python were dissected. The main organs that were dissected and used were the eyelids, retina, brain, and pits. They were then stored in vials that were placed in liquid nitrogen. Samples were then taken from the organs and they were then placed in a solution of picric acid and parafamaldihide. Extremely thin slices were cut from two of the pits with a diamond edge knife, one from a Burmese python and another from a Ball python. The samples taken from the pits were observed with the scanning electron microscope (SEM). Later, gold particles were placed on these pit samples and it was looked at through a transmission electron microscope (TEM). The samples were stained with lead acetate and urinal acetate before viewed with the SEM and TEM. The objective was to find out where the gold particles had ended up. The gold particles were to attach to a specific type of antibody we were trying to find called calmodjulen. When viewed with the TEM, the samples were both in very low contrast, hence it was very hard to see where the gold particles had ended up. It was so hard to see that we finally gave up and determined that the samples must be stained once more before we could spot the gold particles in the pit samples. The next three pages show the surface of the pit from a ball python when viewed with the SEM.

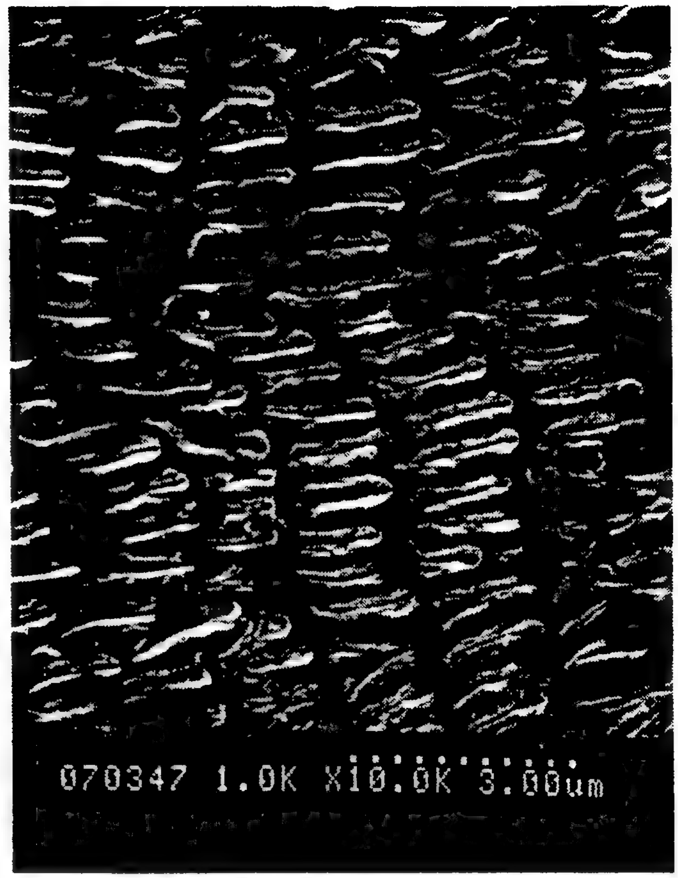


This is the surface of the pit magnified 2,500 times with the SEM
Note that you can see tiny holes on the surface, these are called "mini-pits"



This is the surface of the pit magnified 10,000 times with the SEM
Note that you can see “ridges” running along the surface





These two pictures have been magnified 10,000 times with the SEM.
They were both taken from different places on the pit sample.
Note that the one on the left has the same "ridges" and "mini-pits".
and the one on the right has "mini-scales" in-between the ridges.

Results & Conclusions

The results for PAM were only partially analyzed and further research by Materials Lab researchers on this project will continue.

In the snake project, the gold particles were not found and it was decided that the samples would have to be stained again. Unfortunately, the "snake team" could not stain the samples again due to a lack of time. They will continue conducting their research in a laboratory in West Virginia.

Acknowledgments

Special thanks to Ruth Pachter, Don Wiff, Dan Mclean, Gregg Anderson, Don Church, and Micheal Grace for all their help and support. I would also like to thank Wright Laboratory which made this great summer experience possible.

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Jeremy Mount's report was not available at the time of publication.

METHODOLOGY FOR THE CREATION OF A RANDOMIZED SHOT-LINE GENERATOR

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Final Report for;
High School Apprentice Program
Wright Laboratory

Sponsored by:
Air Force Office of Scientific Research
Bolling Air Force Base, Washington, DC

And

Wright Laboratory

August 1997

METHODOLOGY FOR THE CREATION OF A RANDOMIZED SHOT-LINE GENERATOR

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Abstract

Historically the assessment of target kill was a simple matter of observing whether a crater existed where a target once was. In contrast the smaller, higher precision munitions of today do not produce such obvious evidence of target kill. Therefore a more analytical approach to the assessment of target kill is required. Using lethality assessment codes, lethality experts have been able to predict overall target damage. Although these lethality assessment codes are competent indicators of inflicted structural damage, they are deficient in their ability to generate reliable component damage predictions. To correct this shortcoming component fragility data is being collected upon a variety of components, these include; transformers, fluid circuit breakers, pumps, generators, etc, which might be found in targets of interest. One type of fragility testing consists of impacting steel cubes into a desired component along a random shot-line. The damage incurred by the component is recorded as its fragility data. This is the type of testing discussed within this paper.

Shot-lines used in the testing of component fragility may be created using computer programs. The requirements of such a program stipulate that it must be able to generate both the location and angle at which a cube strikes the component. The methodology of the creation of such a program necessitate the inclusion of a uniformly distributed random number generator, and the derivation of algorithms which properly weight the occurrence of impact locations and angles in accordance with real conditions.

METHODOLOGY FOR THE CREATION OF A RANDOMIZED SHOT-LINE GENERATOR

JOHN D. MURCHISON

Introduction

Historically the assessment of target kill was a simple matter of observing whether a crater existed where a target once was. In contrast the smaller, higher precision munitions of today do not produce such obvious evidence of target kill. Therefore a more analytical approach to the assessment of target kill is required. Using lethality assessment codes, lethality experts have been able to predict overall target damage. Although these lethality assessment codes are competent indicators of inflicted structural damage, they are deficient in their ability to generate reliable component damage predictions. To correct this shortcoming component fragility data is being collected upon a variety of components, these include; transformers, fluid circuit breakers, pumps, generators, etc, which might be found in targets of interest. One type of fragility test consists of impacting mild steel cubes into a desired component along a random shot-line. The damage incurred by the component is recorded as its fragility data.

This paper presents a methodology for the creation of random shot-lines, to be used in the gathering of component fragility data. A FORTRAN 77 compiler was used to construct a computer program which would provide both the orientation of a component during testing and the location upon that component to be imapcted.

Methodology-Random Number Generator

The ability to create a program which produces shot-lines for fragility tests is dependent upon the fabrication of an adequate random number generator. The invention of such a generator, capable of producing uniformly distributed random numbers, may be achieved by a variety of methods. However, it is important to realize that simply performing a series of tangled and indiscriminate mathematical operations upon a seed value is often not enough, perhaps even counterproductive. Therefore it is critical to thoroughly test all generators for emergent patterns. Two common methods of producing generators are the use of the modulo operations and

overflows. A modulo operation yields an answer which is the integer remainder produced by the division of its two arguments. This modulo operation enables the production of a random integer. This is accomplished by, manipulating a seed value, the first argument, taking the modulo of it and the second argument, storing the value as the new seed and repeating the process. Additionally, by altering the second argument the range of the operations results may be controlled. Contrarily the use of an overflow creates a real number between 0 and 1. This is done by causing the computer to compute integers that are too large to store. The part of the number which it is able to store is a random sequence which is used to determine the random number (see Figures 1 and 2).

```
        program random
*
*         DECLARATIONS
        integer i, number, seed, x, y
*
*         SET PARAMETERS (SEED FOR GENERATOR, # OF VALUES)
        print*, 'ENTER A POSITIVE INTEGER SEED VALUE   '
        read*, seed
        print*, 'ENTER # OF VALUES'
        read*, number
*
*         EXECUTION
        do 20 i = 1, number
        do 10 n=1, 3
        seed=int(rrand()*1479+i*seed)
        x = mod((57*seed+1),181)
        y = mod((57*x+1),181)+1
   10  seed=y
       print*, seed
   20  continue
*
       END
```

Figure 1.

Random number generator which produces uniformly distributed integers between 1 and 180 (see Graph 1).

```
      program random
*
*       DECLARATIONS
      integer seed, number
*
*       SET PARAMETERS (SEED FOR GENERATOR, # OF VALUES)
      print*, 'ENTER A POSITIVE INTEGER SEED VALUE'
      read*, seed
      print*, 'ENTER # OF VALUES'
      read*, number
*
*       EXECUTION
      do 10 i=1, number
      seed= int (rrand()*1479+i*seed)
      seed=2045*seed+1
      seed=seed-(seed/1048576)*1048576
      randx=real(seed+1)/1048577.0
      if (randx.lt.0) randx=randx*(-1)
      print*, randx
   10 continue
*
        END
```

Figure 2.

Random number generator which produces uniformly distributed real numbers between 0 and 1.

Methodology-Shot-Line Generation Program

The initial step in creating a program which will generate shot-lines for fragility testing is the creation of a template based upon the dimensions of the component to be tested. This is the equivalent of placing the component within a box based upon its own X, Y, and Z dimensions. Each face of this template is then declared a representative number 1-6 (Figure 3 and 4).

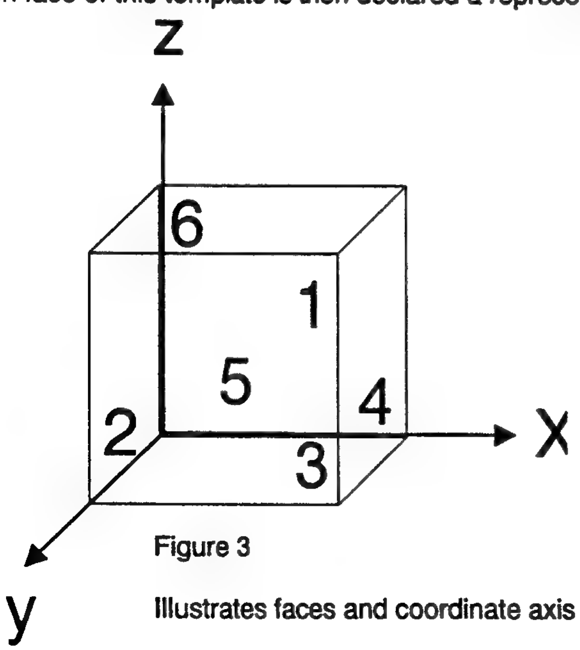


Figure 3

Illustrates faces and coordinate axis

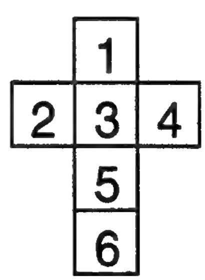
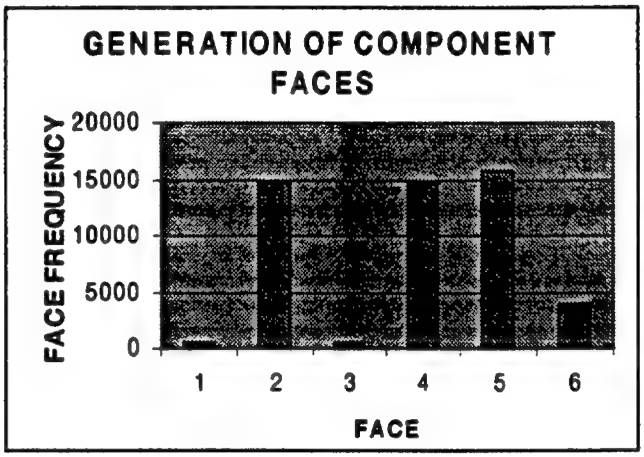


Figure 4

Diagram of component template

Secondly a face of the component template must be selected to contain the location of impact. This selection of a component face is not a totally random one, instead each face is designated a relative position; (1) back, (2) side, (3) bottom, (4) side, (5) front, and (6) top. Each position is then assigned a frequency of occurrence. This is accomplished by altering the modulo based random integer generator to produce numbers 1-100. If the integer selected is 1-30 face 5 is selected, if it is 31-60, face 4 is selected, 61- 90, face 2, 91- 98, face 6, 98- 99, face 1, and 99-100, face 3. These frequencies enable the program to weight the occurrence of each face in a realistic manner. Essentially this means that the program, like an actual fragment, is more likely to select, impact, the front top or side faces of the component than the back or bottom (Graph 1).

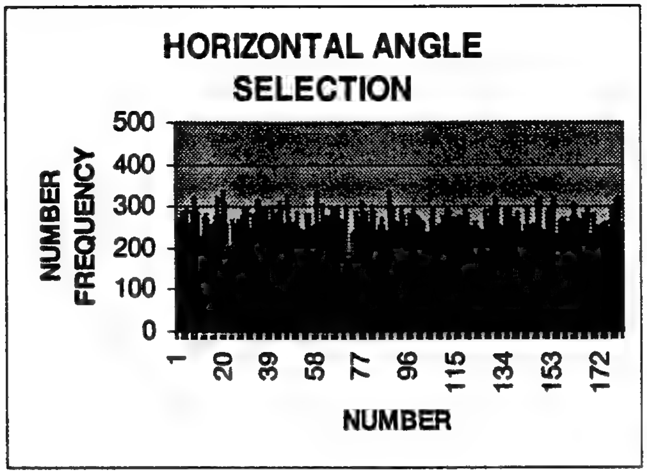


Graph 1

Following the selection of a component face, a location upon that face must be selected as the site of impact. This is accomplished by first multiplying the two relevant dimensions of the selected face, rounded to the next largest integer, to obtain its area in square inches. A grid is then constructed across the template face numbering from the top right and ending with the computed area. This last number is then used as the upper boundary for the selection of a random integer using the modulo based random number generator, producing the location of impact.

To obtain a shot-line applicable in a fragility test a program must include a method of selecting the component's angles of rotation. It is important to remember that when constructing this type of fragility test, it is the position of the component, in relation to the gun, that creates the shot-line. The first angle of rotation is that which occurs through the rotation of the component's z

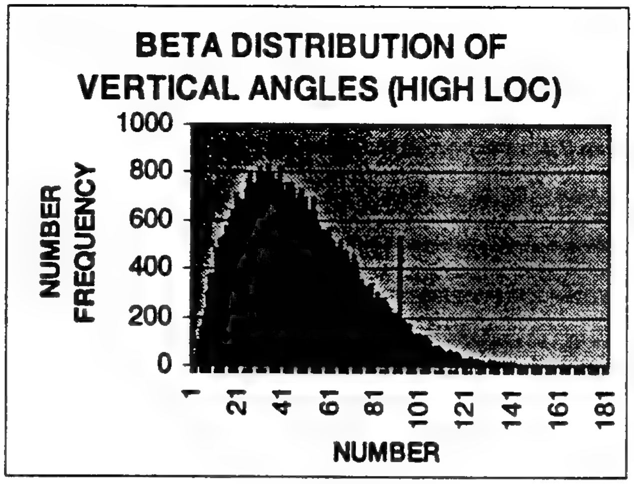
axis, otherwise known as the horizontal angle of rotation. To obtain the horizontal angle of rotation the modulo based random integer generator must be modified to select numbers 0-180, thereby selecting an angle between 0 and 180 degrees (Graph 2).



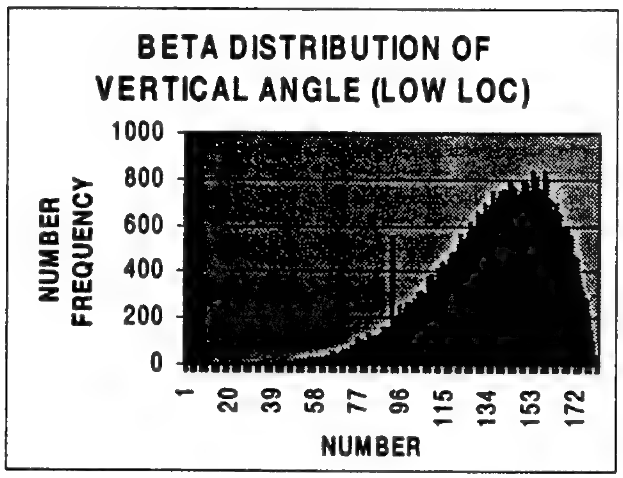
Graph 2

The second angle of rotation is that which occurs when either the x or y axis is rotated, depending upon which face is selected, known as the vertical angle of rotation. Though the vertical angle of rotation may range from –90 to 90 degrees (graphs illustrate range as 0 to 180), the plausibility of many angles is dependent upon the selected impact coordinate, with the exception of faces 3 and 6 (top and bottom). Whereas a fragment striking the center region of a component face may approach by nearly any trajectory, it is highly improbable that a fragment striking the upper region of a component face will approach from a negative angle, and conversely it is highly improbable that a fragment striking the lower region of a component face will approach from a positive angle. Therefore it is necessary to develop a method of weighting the occurrence of vertical angles in both the upper and lower regions of the component face. A polynomial equation capable of doing this was devised by Lt. Col. Bodenschatz, Ph.D. This equation is (7x^6)-(6x^7)-(b)=0. A random number between 0-1generated by the overflow (0-1) generator is inserted for b. The equation is then solved for x using the Newton-Raphson Method. The resulting answer produces a Beta Distribution of angles between –90 and 90. The preceding equation returns vertical angles for the lower region of the component face. A similar symmetric

equation –1((7x^6)-(6x^7))-(b)=0 provides vertical angles for the upper region of the component face (Graphs 3 and 4).



Graph 3



Graph 4

Results

The following table illustrates ten shot-lines produced by the shot-line generation program, including the face selected, location of impact upon that face, and the horizontal and vertical angles selected.

FACE	LOCATION	H ANGLE	V ANGLE
4	121	3	60
5	64	75	73
5	112	23	-68
2	148	109	48
4	103	70	-79
6	91	7	-16
2	148	28	36
4	49	50	-22
4	139	161	33
4	103	42	89

Figure 5

Acknowledgments

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Mr. Don Grosch, Southwest Research Institute

Mr. Don D. Harrison, HSAP Coordinator

Mr. Mike K. Deiler, HSAP Coordinator

Rest of HSAP apprentices

Appendix
Shot-line generating program

```
*-----------------------------------------------------------------------
*         INTEGRATION PROGRAM
*         THIS PROGRAM INTEGRATES THE VARIOUS SUBROUTINES OF THIS
*         PROJECT
*         1) PARAMETERS
*         2) IRANDOM
*         3) SIDE
*         4) GRID
*         5) VROT
*         6) HROT
*          Programs random and vert are to be run after this program,
*          results are written to newtotal.dat
*-----------------------------------------------------------------------
      PROGRAM SHOTLINE
*
*         DECLARATIONS
      common seed, randx, face, loc, xsize, ysize, zsize, dmod,
     +i, quad
      integer i, face, loc, quad, vangle, hangle, xsize, ysize,
     +zsize
*
      open (10, 'facdat.dat')
      open (11, 'locdat.dat')
      open (12, 'vrotdat.dat')
      open (13, 'hrotdat.dat')
      open (14, 'total.dat')
      open (15, 'quad.dat')
      seed=147
      call parameters
      do 10 i=1,20
      call side
      call grid
*
*        DETERMINE VERTICAL ANGLE SELECTION SUBROUTINE
      if (quad.eq.0) goto 1
      if (quad.eq.1) goto 2
      if (quad.eq.2) goto 1
      if (quad.eq.3) goto 2
   1  call avrot (vangle)
      goto 3
   2  vangle=500
      write (15,*) quad
*
   3  call hrot (hangle)
*
*        PRINT SIMULATION RESULTS
*      print*,  'TARGET FACE SELECTED= ', face
*      print*,  '1-inch square selected= ', loc
*      print*,  'angle of vertical rotation= ', vangle, ' DEGREES'
*      PRINT*,  'ANGLE OF HORIZONTAL ROTATION= ', hangle, ' DEGREES'
*
      write (10,*) face
      write (11,*) loc
      write (12,*) vangle
```

```
      write (13,*) hangle
      write (14,*) face, loc, vangle, hangle
*
   10 continue
*
      end
*-----------------------------------------------------------------
*         PARAMETERS
*         THIS SUBROUTINE ESTABLISHES THE PROJECT PARAMETERS
*-----------------------------------------------------------------
      SUBROUTINE PARAMETERS
*
*         DECLARATIONS
      common seed, randx, face, loc, xsize, ysize, zsize, dmod,
     +i, quad
      integer xsize, ysize, zsize
      real xreal, yreal, zreal, intx, inty, intz
*
*         TARGET SPECIFICATIONS
*         ENABLES PROGRAM TO ROUND UP DECIMALS
      print*, 'ENTER THE TARGETS X DIMENSION           '
      read*, xreal
      intx = aint (xreal)
      if (xreal.gt.intx) goto 2
      goto 4
    2 xsize = int (intx+1)
      goto 6
    4 xsize = int (xreal)
*
    6 print*, 'ENTER THE TARGETS Y DIMENSION           '
      read*, yreal
      inty = aint (yreal)
      if (yreal.gt.inty) goto 8
      goto 10
    8 ysize = int (inty+1)
      goto 12
   10 ysize = int (yreal)
*
   12 print, 'ENTER THE TARGETS Z DIMENSION          '
      read*, zreal
      intz = aint (zreal)
      if (zreal.gt.intz) goto 14
      goto 16
   14 zsize = int (intz+1)
      goto 18
   16 zsize = int (zreal)
*
   18 return
      end
*-----------------------------------------------------------------
*         IRANDOM
*         THIS SUBROUTINE GENERATES A RANDOM INTEGER
*-----------------------------------------------------------------
      SUBROUTINE IRANDOM
*
*         DECLARATIONS
      common seed, randx, face, loc, xsize, ysize, zsize, dmod,
```

```
     +i, quad
      integer seed, x, y, dmod, k, i
*
*        SEED NUMBER GENERATOR
      do 10 k =1,3
      seed= int (rrand()*1479+i*seed)
      x = mod((57*seed+1),dmod)
      y = mod((57*x+1),dmod)
      seed=y
   10 continue
*
      return
      end
*-------------------------------------------------------------------
*     SIDE
*     THIS SUBROUTINE CHOOSES A FACE OF THE TARGET OBJECT BY
*     ACCESING THE RANDOM NUMBER GENERATOR
*-------------------------------------------------------------------
      SUBROUTINE SIDE
*
*       DECLARATIONS
      common seed, randx, face, loc, xsize, ysize, zsize, dmod,
     +i, quad
      integer dmod, seed, face
      real randx
*
*       ACCESS RANDOM NUMBER GENERATOR
      dmod=101
      call irandom
      if (seed.lt.0) goto 50
      goto 60
   50 seed=seed*(-1)
   60 if (seed.ge.0.and.seed.le.(30)) goto 1
      goto 2
    1 face=5
      goto 20
    2 if (seed.gt.(30).and.seed.le.(60)) goto 3
      goto 4
    3 face=4
      goto 20
    4 if (seed.gt.(60).and.seed.le.(90)) goto 5
      goto 6
    5 face=2
      goto 20
    6 if (seed.gt.(90).and.seed.le.(98)) goto 7
      goto 8
    7 face=6
      goto 20
    8 if (seed.gt.(98).and.seed.le.(99)) goto 9
      goto 10
    9 face=1
      goto 20
   10 face=3
*
   20 return
      end
*-------------------------------------------------------------------
```

```
*          GRID
*          THIS SUBROUTINE DETERMINES THE NUMBER OF 1 INCH SQUARES UPON
THE
*          FACE SELECTED, SELECTS ONE AT RANDOM, AND ESTABLISHES VALUES
WHICH
*          DETERMINE THE DIRECTION OF WEIGHT UPON ANGLE SELECTION
*          FACE PLAN:
*              1
*            2 3 4
*              5
*              6
*-----------------------------------------------------------------------
           SUBROUTINE GRID
*
*              DECLARATIONS
      common seed, randx, face, loc, xsize, ysize, zsize, dmod, i,
     +quad
      integer seed, face, xsize, ysize, zsize, map, loc, dmod,
     +zrow, quad
      real realz, xreal, yreal, lreal
*
*          MAP THE FACE
*          FACES 1 AND 5
      if (face.eq.1) goto 2
      if (face.eq.5)  goto 2
      goto 4
  2   map = xsize * zsize
*          FACES 2 AND 4
  4   if (face.eq.2) goto 6
      if (face.eq.4) goto 6
      goto 8
  6   map = ysize * zsize
      goto 10
*           FACES 3 AND 6
  8   map = xsize * ysize
*
*          ACCESS RANDOM NUMBER GENERATOR
  10  dmod=map
      call irandom
      loc=seed
*          DETERMINE WHICH REGION LOC IS IN
      if (face.eq.1.or.face.eq.5) goto 20
      if (face.eq.2.or.face.eq.4) goto 30
      quad=0
      goto 40
*
*          DETERMINES QUADRANT OF FACES 1 & 5
   20 realz=real(zsize)
      highquad=int(realz*(5.0/18.0))
      midhalf=zsize-highquad
      xreal=real(xsize)
      lreal=real(loc)
      zrow=int(lreal/xreal)
      if (mod(loc,xsize).eq.0) goto 40
      zrow=zrow+1
      goto 35
*
```

```
*         DETERMINES QUADRANT OF FACES 2 & 4
   30 realz=real(zsize)
      highquad=int(realz*(5.0/18.0))
      midhalf=int(zsize-highquad)
      yreal=real (ysize)
      lreal=real(loc)
      zrow=int(lreal/yreal)
      if (mod(loc,ysize).eq.0) goto 40
      zrow=zrow+1
*
   35 if (zrow.le.highquad) goto 36
      goto 37
   36 quad=1
      goto 40
   37 if (zrow.gt.highquad.and.zrow.le.midhalf) goto 38
      goto 39
   38 quad=2
      goto 40
   39 quad=3
*
   40 return
      end
*-----------------------------------------------------------------------
*         AVROT
*         THIS SUBROUTINE RANDOMLY SELECTS THE TARGET'S VERTICAL
*         ANGLE OF ROTATION (UNIFORM DISTRIBUTION)
*-----------------------------------------------------------------------
      SUBROUTINE AVROT (vangle)
*
*         DECLARATIONS
      common seed, randx, face, loc, xsize, ysize, zsize, dmod,
     +i, quad
      integer seed, vangle, dmod
      real randx
*
*         ACCESS RANDOM NUMBER GENERATOR
  10  dmod=181
      call irandom
      if (seed.ge.91) goto 1
      goto 2
   1  seed=(seed-90)*(-1)
   2  vangle=seed
*
      return
*
      end
*-----------------------------------------------------------------------
*         HROT
*         THIS SUBROUTINE RANDOMLY SELECTS THE TARGET'S ANGLE OF
*         HORIZONTAL ROTATION (UNIFORM DISTRIBUTION)
*-----------------------------------------------------------------------
      SUBROUTINE HROT (hangle)
*
*         DECLARATIONS
      common seed, randx, face, loc, xsize, ysize, zsize, dmod,
     +i, quad
      integer seed, hangle, dmod
```

```
*
*          ACCESS RANDOM NUMBER GENERATOR
  10  dmod=181
      call irandom
      hangle=seed
      if (hangle.lt.0) goto 1
      goto 2
   1  hangle=hangle*(-1)
*
   2  return
*
      end
*-----------------------------------------------------------------------
```

```
*-----------------------------------------------------------------------
      program random
*
      open (10,'testdat.dat')
      integer seed
*
      seed=147
      do 10 i=1, 20
      seed= int (rrand()*1479+i*seed)
      seed=2045*seed+1
      seed=seed-(seed/1048576)*1048576
      randx=real(seed+1)/1048577.0
      if (randx.lt.0) randx=randx*(-1)
      write (10,*) randx
   10 continue
*
      end
*-----------------------------------------------------------------------
```

```
*-----------------------------------------------------------------------
      program Vert
*
      open (6,'face.dat')
      open (10,'testdat.dat')
      open (14,'total.dat')
      open (15,'quad.dat')
      open (16,'newvrot.dat')
      open (17,'newtotal.dat')
      integer b, i, loc, face, vangle, hangle
*
*     newton
*     newton-raphson method
*     solve for x given: (7.0*x**6.0)-(6.0*x**7.0)-(b)=0
*     change lines 20, 70, 90 and 210 to define new function
*
      do 300 i=1,20
      read (14,*) face, loc, vangle, hangle
      read (15,*) quad
      if (vangle.eq.500) goto 1
      goto 400
    1 read (10,*) randx
```

```
      b=randx
      it=1
      t=.00001
*
*     t=tolerance
      c=.75
   67 r=c
   68 x=r
*
*     the function
      f=(7.0*(x**6.0))-(6.0*(x**7.0))-(b)
      it=it+1
*
*     the derivative
      fp=(42.0*(x**5.0))-(42.0*(x**6.0))
      if (fp.lt..00000001) goto 70
      goto 74
   70 c=c+.05
      goto 67
   74 h=-f/fp
*     fp=f prime (derivative)
*
*     find the new root rn
      rn=r+h
      d=abs(r-rn)
*
*
      if (it.gt.100) goto 170
      goto 172
  170 c=c+.05
      goto 67
  172 if (d.gt.t) goto 174
      goto 176
  174 r=rn
      goto 68
  176 if (rn.gt.1.0) goto 178
      goto 400
  178 c=c+.05
      goto 67
*
  400 vangle=(r*180)-90
      if (quad.eq.1) goto 401
      goto 402
  401 vangle=(-1)*(vangle)
  402 write (16,*) vangle
      write (17,*) face, loc, vangle, hangle
  300 continue
*
      end
*------------------------------------------------------------------------
```

Disha Patel's report was not available at the time of publication.

EMPIRICAL CHARACTERIZATION OF MID-INFRARED PHOTODETECTORS FOR A DUAL-WAVELENGTH LADAR SYSTEM

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Empirical Characterization of Mid-Infrared Photodetectors
for a Dual-Wavelength LADAR System

Neill W. Perry
Crestview High School

Abstract

Spectral measurements were conducted on silicon (Si) and germanium (Ge) avalanche photodetectors. Detector characterization was computer automated using LabVIEW, a graphical programming language. The collected data provides the information necessary to design individual receiver circuits for both of the specific devices, enabling either to be incorporated into a dual-wavelength laser radar (LADAR) system.

Empirical Characterization of Mid-Infrared Photodetectors
for a Dual-Wavelength LADAR System

Neill W. Perry

Introduction

Laser radar (LADAR) imaging systems are used for guidance, target recognition, and surveillance. They operate by monitoring reflected pulses, much like conventional radar. However, laser radar systems have a shorter wavelength than microwave radar, thus providing higher resolution. In addition to providing detailed images, LADAR's high carrier frequency also allows for the detection of small objects and the determination of physical characteristics, such as shape, size, velocity, rotation rate, and vibration. The primary disadvantage of LADAR is its difficulty penetrating clouds and precipitation.

Current LADAR systems are also unable to distinguish between materials like wood, metal, and plastic. Each of these materials has a varying spectral reflectivity; in other words, the object's reflection of light changes with respect to wavelength. It is anticipated that this characteristic can be exploited by a dual-wavelength laser radar system to discriminate manmade targets, such as tanks, from natural background, like trees.

To test laser radar's potential to identify target components, a dual-wavelength LADAR system is being constructed. By emitting two pulses of light at different wavelengths (1.5 μm and 1.06 μm) the LADAR unit will be able to collect the data necessary to determine each object's spectral reflectivity. These comparisons will determine LADAR's success at identifying specific materials. Longer wavelengths may be necessary to fully exploit the spectral reflectivity variations. Although commercial photodiodes are available to detect 1.5 μm reflections, newer experimental materials are required to detect signals in the 2-5 μm band. The properties of these new materials must first be characterized to be properly utilized in a LADAR system. An automated measurement system is desirable to expedite this characterization process.

Objectives

The primary objective of this project was to determine operating characteristics of various photodetectors for potential use in a dual-wavelength laser radar system. This was accomplished in three steps. First, LabVIEW programs were written to control laboratory equipment from a computer terminal. Second, the equipment was calibrated using spectral lamps, an optical multichannel analyzer, and an optical power meter. Finally, automated characterization tests were conducted on two photodetectors using the LabVIEW programs. The data collected from these measurements was used to calculate the spectral response of each detector; in other words, its sensitivity with respect to wavelength.

LabVIEW

Laboratory measurements of spectral response require equipment such as an optical power meter, a monochromator, and a lock-in amplifier. To facilitate the testing procedure, LabVIEW programs were written to automatically control the equipment and record measured data through a General Purpose Interface Bus (GPIB). A

description of LabVIEW can be found in the LabVIEW User Manual. The following is an abridged version of that text:

> LabVIEW is a general purpose programming system. Instead of using a text-based language to write lines of code, LabVIEW uses a graphical language to create programs in a block-diagram form. LabVIEW's advantage over other software lies in its ability to fashion a virtual instrument, or VI, for the user. LabVIEW programs are called virtual instruments because their appearance and operation imitate actual instruments. Characteristics of a virtual instrument include an interactive user interface, a source code equivalent, and acceptance of instructions from higher level VI's.
>
> The interactive user interface, or front panel, simulates the control panel of a physical instrument. The front panel can contain knobs, dials, and other controls and indicators. It also accepts input parameters and displays output data as customized by the programmer.
>
> LabVIEW programs are written in a block diagram form. This graphical language provides a visual representation for each traditional computer logic. Each pictorial block may be the source code equivalent of a Boolean case, or a While Loop, or anyone of the many preprogrammed LabVIEW functions. The flow of data is decided by wires that run from output and input terminals located on each block.
>
> Another feature of LabVIEW is its ability to receive instructions from other VI's. This aspect permits LabVIEW programs to be hierarchical. A virtual instrument constructed to control an entire process can divide the procedure into a series of simple tasks. Each subroutine could then be assigned to a lower level VI which would have that one task as its only function. This scheme of modular programming makes debugging quick and easy.

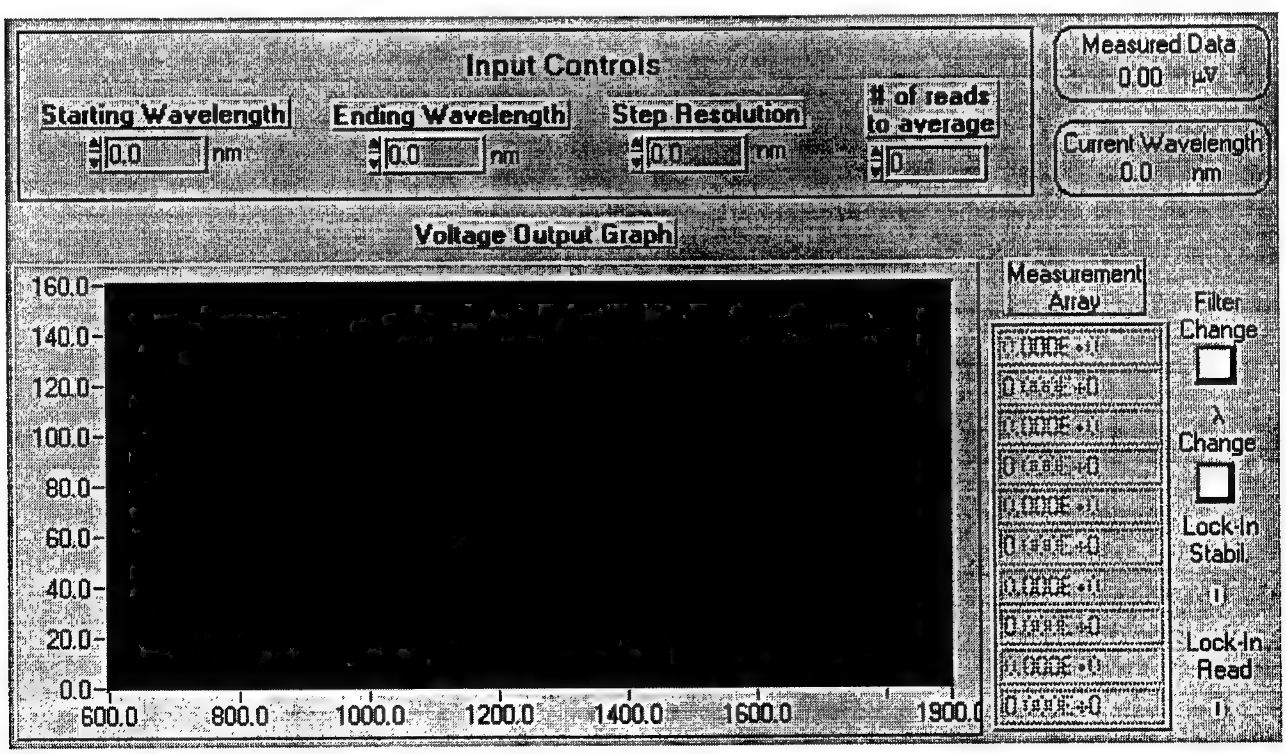

Figure 1: LabVIEW Front Panel

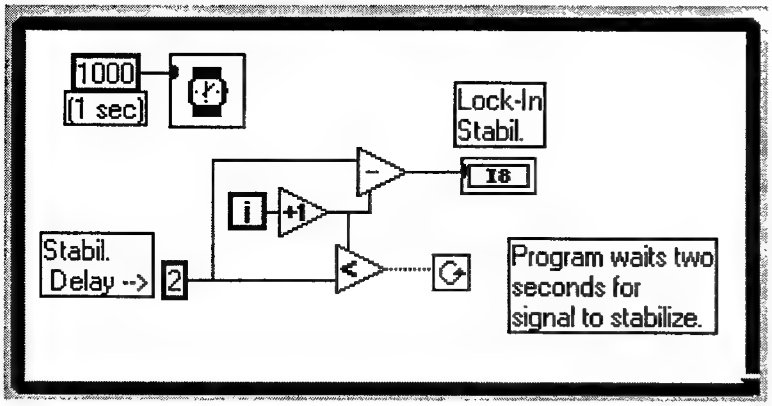

Figure 2: Graphical Programming Language

The programs written for this project demonstrate each of these characteristics. Figure 1 above shows the front panel of the Master VI, the main routine which performs a spectral scan. The front panel consists of input controls, display indicators, and the output graph. Prior to performing a scan, the operator adjusts the input controls to the desired settings. As the program executes, the graph and other indicators monitor progress. Figure 2 illustrates the LabVIEW programming format. The particular structure shown is a While Loop which counts off a two-second delay. The While Loop runs as long as the interval count (i+1) is less than the preset value (2). The loop pauses for one second (1000 milliseconds) during each cycle, and displays the countdown on a front panel indicator. The hierarchy of the Master VI is diagrammed in Figure 3. The Master VI calls upon ten lower VI's to perform specific subroutines. Each "sub" VI can receive instructions from and transfer data back to a higher VI. This modular approach simplifies the programming complexity, makes for easier debugging, and is transparent during operation by the end-user.

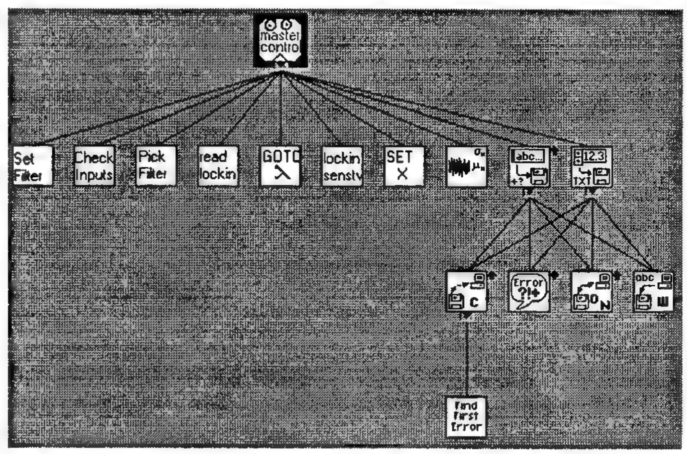

Figure 3: VI Hierarchy

Calibration

To obtain the calibrated spectral response of each photodetector, the light source used to illuminate it must also be calibrated both in wavelength and output power. A calibrated optical multichannel analyzer (OMA) was used as a spectrometer to measure the wavelength, whereas a calibrated power meter was used to measure the optical power. As described in its User Manual, the OMA is "a computer-controlled multichannel spectroscopic system capable of detecting, measuring, and manipulating spectra at high acquisition rates." Essentially, it is a spectrometer with a 512-element InGaAs detector array attached at the exit slit. The OMA is calibrated by identifying measured peaks with known wavelengths from spectral calibration lamps. These lamps contain elemental gases, such as neon, krypton and xenon, and emit light at discrete, narrow wavelengths. Light from these spectral lamps was focused into the entrance slit. The OMA measurement was displayed, and the peaks on the graph were matched up with the specific wavelengths known to be produced by the particular element. Using this technique, calibration files were created for operation over the entire InGaAs detector responsivity range, 0.9 μm to

1.6 μm. Specific calibration files are then activated by the user when data is to be collected. After calibrating the OMA detector array, the monochromator light source can be calibrated by focusing its output light into the tuned OMA.

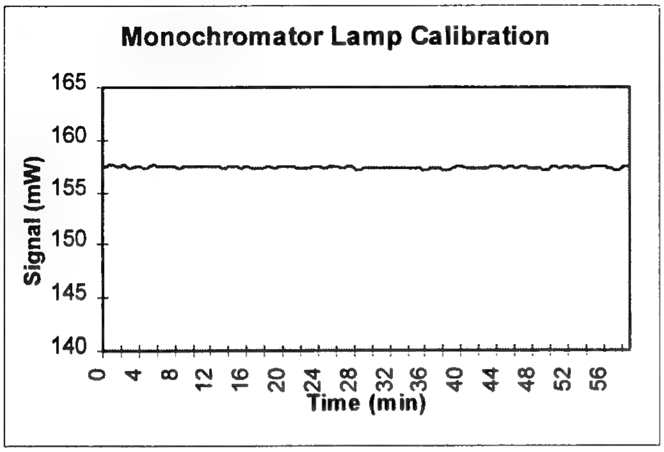

Figure 4: Lamp Output Graph

Measurements were taken to determine the stability over time of the tungsten halogen lamp used as the light source within the monochromator. The data shows less than 0.4% variation over a period of one hour (see Figure 4). Because of this stability, spectral measurements of test devices can be normalized by initially performing a spectral scan of the monochromator with a calibrated power meter.

Calibration scans were also run on the monochromator to quantify its output power as a function of wavelength. An optical multimeter collected the signal using both silicon and germanium power/waveheads. A LabVIEW calibration VI was used to control the calibration scan by setting the output wavelength, pausing for signal stabilization, gathering multiple measurements, then averaging the data. This process repeats for each integral wavelength value in the selected scanning range. By determining the monochromator's signal strength at each wavelength, a photodetector's responsivity can be expressed in amps per watt.

Experimentation

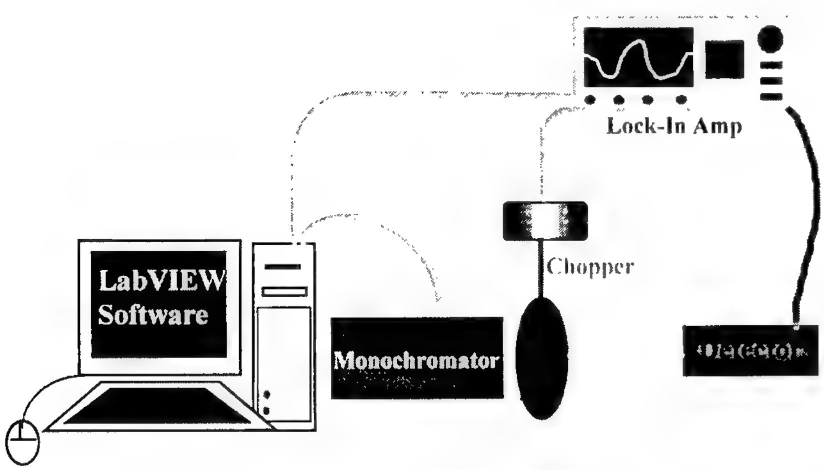

Figure 5: Testing Set-Up

The final phase of this project was to conduct spectral characterizations of silicon and germanium photodetectors. Laboratory equipment was set-up as shown in Figure 5. The monochromator produces light at a single wavelength, which is then focused into the detector. The diode is connected to a lock-in amplifier. A chopper modulates the signal, thus providing a reference frequency of 350 Hz for the amplifier. Communication between LabVIEW software and instrumentation hardware is carried through GPIB cable.

The scan is initially configured by setting several parameters in the LabVIEW front panel, such as beginning and ending wavelength of the scan, scanning step increments, and the number of measurements to be

averaged. Testing is automated by the LabVIEW program Master VI, which functions very similar to the VI used for power calibration. The program sets the monochromator's output wavelength, pauses for signal stabilization, then adjusts the lock-in amplifier to its highest sensitivity without overloading the amplifier. Multiple measurements are collected, averaged, and displayed on the output graph. The standard deviation of these measurements is calculated to indicate the signal's stability. The VI then increases the wavelength by the preset increment value and repeats the process. At the end of the scan the user has the option of saving the data array to a spreadsheet file for further analysis. The scans for this project usually lasted two hours.

Data Analysis

The spectral responsivity, expressed in amps per watt, of both of the photodetectors was calculated. As shown in equation (1), this was accomplished by dividing the data from the characterization scan, measured in volts (V), by the resistance of the load (R), measured in ohms, and the data from the monochromator's power calibration (P), measured in watts. These computations convert the collected data into a function of amps per watt, or A/W. Figures 6 and 7 display each detector's calculated spectral responsivity, measured in A/W. Note that the diodes were scanned only over their specific spectral ranges.

$$\frac{I}{P} = \frac{V}{(P \times R)} \tag{1}$$

Conclusion

The experiments conducted during this project gathered sufficient data to calculate the calibrated spectral responsivity of silicon and germanium photodetectors. This information is necessary for the design of high-performance receiver circuits. Construction of several units will provide future users a choice of sensors and allow them to take advantage of the different spectral properties of the detector materials. Once the dual-wavelength LADAR system is assembled, testing can begin to determine if laser radar can recognize different materials based upon comparisons of their spectral reflectivity.

Acknowledgments

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The support of the High School Apprenticeship Program administrators: Don Harrison, Mike Deiler, and Jeanette Williams.

My family: Pa, Ma, Kyle, Regina, and Hugh.

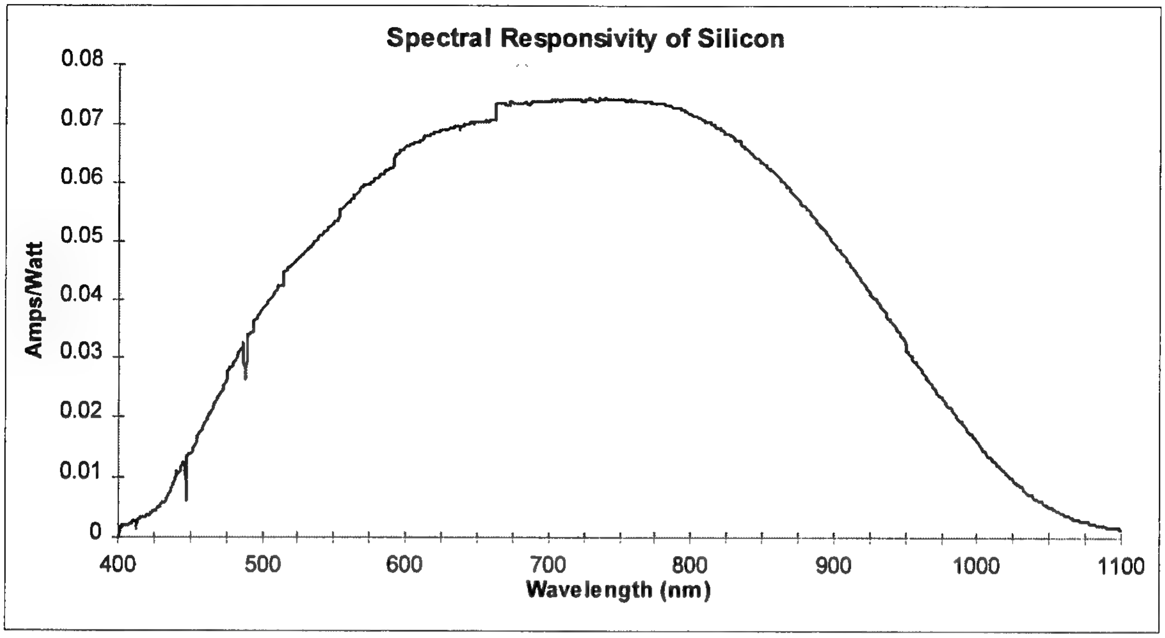

Figure 6: Responsivity Curve of Silicon Photodetector

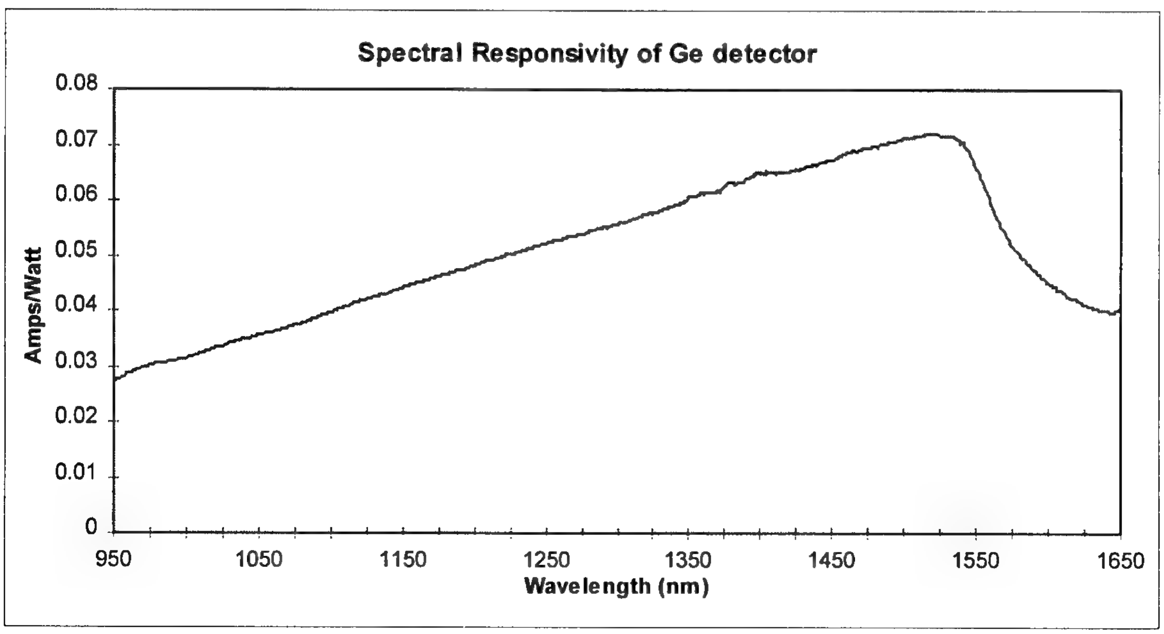

Figure 7: Responsivity Curve of Germanium Photodetector

Equipment

The following equipment was used during this project:

SpectraPro 275 Monochromator/Spectrograph - Acton Research Corporation

OMM-6810B Optical Multimeter - ILX Lightwave Corporation

OMH-6722B Silicon Power/Wavehead - ILX Lightwave Corporation

OMH-6727B InGaAs Power/Wavehead - ILX Lightwave Corporation

LabVIEW for Windows Version 3.0.1 - National Instruments

ST-121 Optical Multichannel Analyzer - Princeton Instruments

WinSpec Software Version 1.6 - Princeton Instruments

SR510 Lock-In Amplifier - Stanford Research Systems, Inc.

SR540 Chopper Controller - Stanford Research Systems, Inc.

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Winspec: User's Manual. Princeton Instruments, inc. 1996.

THE IMPLICATIONS OF PHOTOMODELER ON
THE GENERATION OF 3D MODELS

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THE IMPLICATIONS OF PHOTOMODELER ON THE GENERATION OF 3D MODELS

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Abstract

Computer models are used in many ways, especially in automatic target recognition algorithms. Therefore, it is important to be able to quickly and accurately generate three-dimensional (3D) models for these purposes. The existing method was very time-consuming, so another method needed to be found. PhotoModeler, a program developed by Eos Systems, Inc., was explored for this purpose. PhotoModeler, a photograph-based modeling program, builds three-dimensional wireframe models from light-ray equations, camera information, and marked points. Results indicated that PhotoModeler models could be generated more quickly and easily than models generated with the previous method, without sacrificing accuracy. Some difficulties were encountered with memory limitations and scaling errors. A series of tips and observations were advanced based on the PhotoModeler modeling experience.

THE IMPLICATIONS OF PHOTOMODELER ON THE GENERATION OF 3D MODELS

Kathleen Pirog

Introduction:

Three-dimensional (3D), computer-generated models have many uses. They are used in computer animation, simulation, design, detection systems, and automatic target recognition (ATR) algorithms. Obviously, an easy and time-efficient way to generate these models is needed. My task this summer was to explore one such modeling method for its usefulness, timeliness, and ease of use.

Problem:

At Wright Laboratory Armament Directorate, 3D models are often used in ATR algorithms, especially those designed for laser radar (LADAR) sensors. A problem existed with the generation of these models, however. Models were made through a tedious, time-intensive process of entering the 3D coordinates of each vertex of each facet in counterclockwise order. If a target was not available for measurement, estimates had to be made about the size of wheels, radar dishes, hatches, and other details. Mistakes were easily made in the entry process, and it took even an experienced modeler two or more days to generate a useable model. PhotoModeler, a computer modeling program developed by Eos Systems, Inc., needed to be tested for its potential worth in this situation. Ease of use, accuracy, needed input, and completion time were all factors to be investigated.

Methodology:

PhotoModeler is a photo-based modeling program. Therefore, the type of pictures imported into the program to be used in the modeling is very important. PhotoModeler can import a variety of image files and will accept photographs from digital cameras, PhotoCD's, video cameras, and photo and negative digital scanners. In this test, photographs from both the Kodak DCS 200 digital camera and a flatbed

scanner were used. The PhotoModeler manual gave several guidelines for taking photographs that would work well in a modeling project. These were followed as closely as possible in the field. They are:

1. Get good angular separation between photographs (close to 90°).
2. Get good photograph overlap.
3. Encircle the target, and try to get photos from above and below.
4. Fill up the photograph with the target.
5. Each point to be imaged should appear on three photographs, more for increased accuracy.
6. Take many pictures; use only those needed.

On test ranges at Eglin Air Force Base, a Kodak digital camera was used to photograph a collection of mobile targets. Four to eight photographs of each target were taken. A sample of the data recorded for a target is listed in Table 1. For some targets, previously taken photographs were digitized using a digital scanner.

Table 1. Data recorded for targets.

Shot Description		Camera Type	Distance from Target
front left corner	**SA-6tel (D61) travel position**	Kodak 200 DCS	15 ft
front right corner		Kodak 200 DCS	15 ft
front		Kodak 200 DCS	13 ft
left side		Kodak 200 DCS	22 ft
back left corner		Kodak 200 DCS	16 ft
back right corner		Kodak 200 DCS	16 ft

The modeling process involves several stages. These include importing photographs into the project, orienting the camera stations, marking points to be modeled, referencing matching points to each other, checking the acceptability of the project data, and processing the 3D model.

To begin the modeling process, a new project was set up in PhotoModeler. The model name, type of camera used, and rough size and shape of the object to be modeled were entered. Digitized photographs stored in the .tif image format were then imported into the project.

Camera station orientation was the next step. An approximate camera position and distance from the target was entered for each photo. Camera information, such as focal length and format size, was entered. This could be done by either positioning a wireframe box around the target in the photograph or by entering known data about camera distance to target and camera type manually.

After orientation had taken place, marking could occur. Marking utilizes three tools to create points, lines, and triangular surfaces over the photograph. Each point to be modeled must be marked. Lines connecting two or more points are drawn in next. These will form the edges of wheels, missiles, hulls, and other details in the finished model. Finally, triangular surfaces are added, creating the facets that will make up the solid body of the model.

The referencing stage comes next. In order to be modeled, each point must be marked on two or more photographs. Referencing allows the modeler to select a point on one photograph and then register it with other points on the remaining photographs. For example, to reference the point on the tip of the leftmost missile of a SA-6 transporter-erector-launcher (TEL) on three photographs, the operator would click on this point on all three photographs with the reference tool to let the computer know that the three points were the same point on the target. Referencing is commutative. If a point on photograph A is referenced to a point on photograph B and to a point on photograph C, the points on B and C are also referenced to each other.

Auditing the project data is the final step before processing. The success of the processing depends on several aspects of the project, and the auditing dialog simply relates facts about these aspects and whether or not the current state of each aspect is favorable to processing. Categories include number of points, number of photographs, points per photograph, average angle between photographs, point coverage, number of points marked on one photograph, number of points marked on two photographs, and point tightness. Each category is evaluated and a yes, maybe, or no answer to the question of acceptability is given.

Processing is the final step in the model-making process. PhotoModeler uses light ray equations, point data, and camera information to locate each marked point in space. The processed model can be viewed in the 3D Model Viewer, where it can be rotated and viewed from any angle. It can be viewed in orthographic or perspective views. The model can show any combination of points, lines, and surfaces. A processed model can be exported in two file formats: .dxf or .vrml.

Results:

Using PhotoModeler, I created nine models. Each took different amounts of time, encountered different problems, and met with varying degrees of success. They include the SA-6 TEL (Figure 1.), SA-6 Radar (Figure 2.) in two configurations, SA-8 TEL (Figure 4.)in two configurations, the SA-8 reload

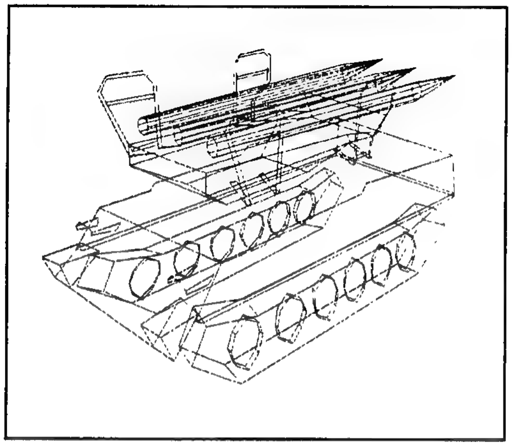

Figure 1. SA-6 TEL

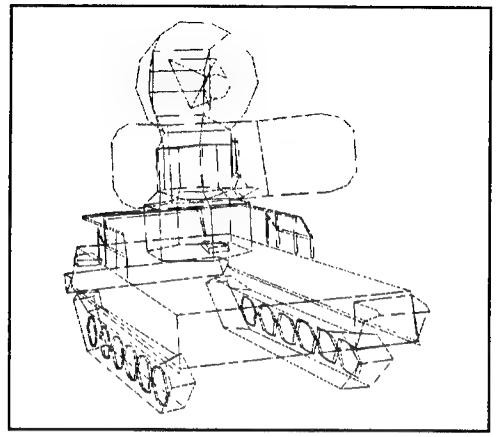

Figure 2. SA-6 Radar

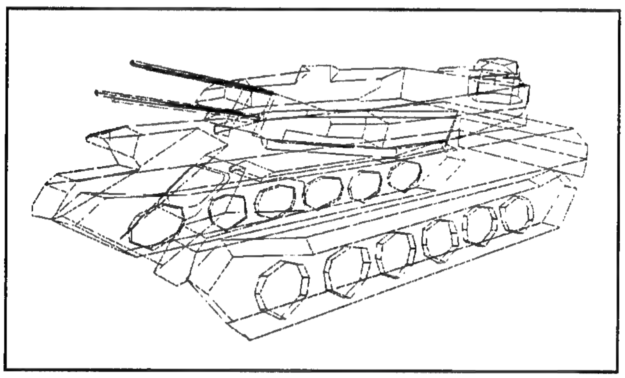

Figure 3. ZSU-23/4

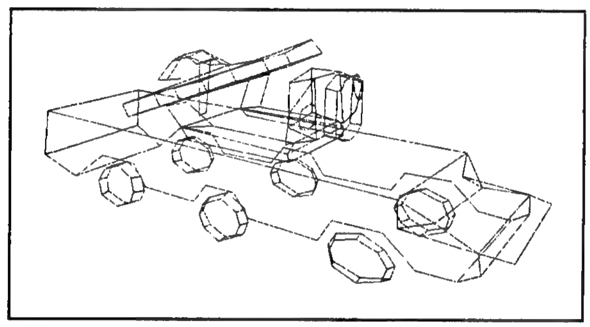

Figure 4. SA-8 TEL

vehicle, ZSU-23/4, SCUD B, and SA-13 TEL. Overall, the results of my PhotoModeler work were fairly good. In general, model shape was right, scale was within .5 meters of the actual target size, and surface coverage was good. Details about each model's peculiarities follows:

Model Description: SA-13 TEL fire position
Location: C:\Katie\13up E:\13up (PhotoModeler disk)
Photo Location: E:\album8\sa-13\D30_1 to D30_6 (OPEL II 2of 2 disk)
Comments: This model has yet to be scaled. This model has very few shape distortions, and I was able to put surfaces on everything except one triangle beneath the missile boxes.

Model Description: SA-6 Radar travel position

Location: C:\Katie\6raddown E:\6raddown (PhotoModeler disk)

Photo Location: C:\Katie\photogra\D60_1 to D60_8

Comments: The scale is very accurate on this model (.1-.2 m) and surface coverage is good, but because of the crowded nature of the dish area, the dish and its supports are distorted. I had to fudge it a little there. This is the kind of target that would benefit from a higher viewpoint photograph, such as one taken from a tower. There are some other photos of the target that are on the OPEL II 2 of 2 disk, but none of them have the proper angle to resolve this difficulty.

Model Description: SA-6 Radar up position

Location: C:\sa-6 E:\sa-6 (PhotoModeler disk)

Photo Location: E:\SA-6, SA-6A, SA-6B, SA-6C, SA-6D (PhotoModeler disk)

Comments: This model turned out surprisingly well for being the first one I did. It was also the only model based on previously taken photographs to succeed. The scale is accurate to about .3 m, and only one or two areas on the radar dish support are lacking surfaces.

Model Description: SA-6 TEL

Location: C:\Katie\sa-6tel E:\sa6tel (PhotoModeler disk)

Photo Location: C:\Katie\photogra\D61_1 to D61_6

Comments: The scale on the body of this model is pretty good (the length is off about .2 m), but the missile length is about 1 m too long. Surface coverage is very good, and the shape is right. The computer is at the end of its memory limit on this model, so if any more lines are added, the lines making up the back end of the model will start to disappear.

Model Description: SA-8 TEL antenna down

Location: C:\Katie\sa-8 E:\sa-8 (PhotoModeler disk)

Photo Location: C:\Katie\photogra\D11_1 to D11_7

Comments: The scale on this model is accurate to within .5 m and surface coverage is pretty good. I did miss one big area between the supports for the missile boxes (which aren't really there, I had to fudge them since the pictures don't show the region under the missile boxes clearly). The shape of this model is ok, but I have had some problems with it looking slightly curved or longer on one side.

Model Description: SA-8 TEL antenna up

Location: C:\Katie\sa-8up

Photo Location: E:\album8\sa-8\D11up1 to D11up5 (OPEL II 2 of 2 disk)

Comments: The computer ate my model! I was saving it when the computer crashed and now it says that it is no longer in a valid .pmr format. I don't know how to fix this and haven't had time to redo the whole model. It was finished, too. I don't think I had scaled it yet, but I know the shape was better than that of the antenna down model, and surface marking had been completed. Maybe someone can resurrect this one, or if not, I guess it'll have to be done over. In any case, I used two photos from the antenna down model (the side shots) to keep the photo configuration I like. They worked fine as long as I didn't mark the antenna on those two photos.

Model Description: SA-8 reload vehicle

Location: C:\Katie\sa8load E:\sa8load (PhotoModeler disk)

Photo Location: C:\Katie\photogra\D10_1 to D10_5

Comments: For some mysterious reason, the scale is really off on this model. If I set the width to the right measurement, the length is 2.5 m too long. If I make the length right, the width is too small. I can't seem to fix it. When I originally began this model, the processing failed frequently even though the audit dialog showed all "yes" acceptable answers. Maybe this had something to do with it. I finally got a decent processed model, but then there were the scale errors. But the shape looks right, and surface coverage on this model is fine.

Model Description: SCUD B

Location: C:\Katie\scud E:\scud (PhotoModeler disk)

Photo Location: C:\Katie\photogra\R23_1 to R23_6

Comments: This is not one of the best models. I was unable to find dimensions with which to scale this model, but have since been told that they might be comparable with those of the MAZ-543 P. The shape is right, though angled strangely, like a cardboard box stood on one corner and pressed on a little to push the edges out of line with each other. This may be fixable. Surface coverage is ok; it's only missing one little area under the tail of the missile.

Model Description: ZSU-23-4

Location: C:\Katie\zsu E:\zsu (PhotoModeler disk)

Photo Location: E:\D01_1 to D01_5 (PhotoModeler disk)

Comments: The computer is also at its memory limit on this one. No more lines can be added without some disappearing from the sides and front of the wireframe model. The shape of this model is pretty good, and surface coverage is good everywhere except at the top. The top was hard to see in the photos, so on both the modeling and surfacing stages of building this model, some detail and surface area were

missed. This model also might benefit from a high-angle photo or two. The scale on this model is very accurate (.1 m).

Conclusions:

Through my work with PhotoModeler, I learned several things that are important to know to increase the success of the modeling. Digital photographs taken specifically for PhotoModeler worked much better than the digitized photographs originally taken for other purposes. These other photos were taken with a camera for which the make and model had not been noted (camera knowledge is needed in the orientation stage) and the target did not fill up enough of the photograph. A desired camera configuration was deduced. I found that one shot from each corner, one from the front, and one from each side worked best. If not enough photos had been taken for this configuration, photos could be flipped in Adobe Photoshop to fill in the gaps. For example, if only the left side of the SA-6 Radar had been photographed, the left side photo could be exported to Adobe Photoshop, copied, flipped horizontally, and imported to PhotoModeler for use as the right side.

Orientation was one of the hardest stages to master. Manually entering position and camera data was not possible in most cases. In these instances orientation could only be accomplished by manipulating the wireframe box and camera parameters. I found, however, that total accuracy in this stage was not essential for processing success. As long as the box was fairly close to its ideal position, the computer was able to reposition it during the processing stage. Also, it is important to ensure that the wireframe box is facing the proper direction. I had processings fail several times because I had oriented the camera stations incorrectly so that the back of the target was being used as the front.

By remembering that referencing is commutative, a lot of time can be saved in the marking and referencing stages. It is not necessary to draw in lines or surfaces on every photograph, as long as they are eventually going to be referenced together. If two points that are connected by a line are referenced to two unconnected points on another photograph, PhotoModeler will draw in the line. Therefore, lines and surfaces only have to be marked on one or two photographs. Referencing errors can be made fairly easily, so care must be taken. In some cases, geometric visualization skills were needed to complete the marking

of a photograph. A bush on one photograph might obscure a wheel seen clearly on two other photographs. The wheel must be marked anyway, so geometric visualization skills were used to put the marks where the edges of the wheel would be. In most cases, little accuracy was lost by the occasional use of this method.

Auditing is not the be-all, end-all processing success indicator. Several models with no's and maybe's mixed in with yes's processed perfectly, while others with all yes's failed repeatedly. Processing itself was variable. Depending on the detail of the model, it took up to 20 minutes to complete a model on a 133 MHz computer. Some models came out looking perfect while others looked mangled or skewed.

Overall, PhotoModeler has some definite advantages and disadvantages for modeling. On the positive side, it has a very user-friendly interface. With experience and good input photographs, accurate models can be made in about six hours, considerably faster than the two days previous modeling techniques took. The models generated are fairly accurate. Plus, PhotoModeler can, given the distance between two points, scale the rest of the project. This reduces the amount of a priori knowledge of the target needed and eliminates much of the guess factor. On the other hand, projects built without custom-taken photos tend to encounter more problems than those built with custom photographs. Sometimes, unexplainable processing failures become frustrating. Uncorrectable skews or scaling errors can occur. The file formats that PhotoModeler uses to export models are not congruous with the formats already in use in ATR algorithms. The process of finding a way to change the files into a useable format was not within my skill level and had to be left to someone else. Computer memory limitations cut down on the detail in some models. If more lines were added, the first ones would start to disappear. This might have been correctable by increasing the memory capabilities on the machine PhotoModeler was running on. Also, the computer that PhotoModeler was installed on crashed frequently, greatly adding to my frustration levels.

While there are some definite faults, on the whole PhotoModeler looks promising for the generation of 3D models. With skill, a good computer, and a little experience, accurate models could be made much more quickly and easily than they currently are. Plus, with the skills and tricks I have learned, the next person to use PhotoModeler should be able to generate good models after less of a learning period.

On a more personal note, I feel that I have learned a lot this summer. I have fulfilled my task, in that I have learned how to use PhotoModeler. I have tested it and found that it does have potential

implications on the generation of 3D models. I have gained familiarity with Windows 95, PowerPoint, and Excel, which I had not had the opportunity to use before. I also learned basic UNIX commands, although I was unable to use them after our network privileges were revoked. I learned how models are used in ATR algorithms. My geometric visualization skills were improved when I was forced to draw in hidden points. Besides this sort of knowledge, I also gained work experience and had the opportunity to explore career options. I feel that I have benefited from being in a professional work environment.

Acknowledgments:

I would like to thank the following people for their help and support:

- Ms. Karen Norris-Zachery, my mentor, who set me up with this project, got me started, and was always willing to take time out to explain anything to me.
- Mr. Deiler, for coordinating the HSAP program and especially for scanning in pictures and fixing my schizophrenic computer over and over and over and over…
- Mr. Harrison, for coordinating the HSAP program and for shooting me point-blank in the face with a water gun at the picnic.
- Ms. Williams, for always ensuring I got paid on time.
- All the people in the RSPL and the IPL, for sharing their experience and their computers with me, and for bringing me a fan when the air conditioner in the RSPL broke down.
- My fellow HSAPs, especially the Building 13 lunch bunch and the popcorn crew!

THE WORLD WIDE WEB AND HYPER TEXT MARKUP LANGUAGE

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Final Report for:
High School Apprentice Program
Wright Laboratory

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and

Wright Laboratory

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THE WORLDWIDE WEB AND HYPER TEXT MARKUP LANGUAGE

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Heritage Christian School

Abstract

I created back to back web pages all summer and found new ways of presenting the information for the user by using image maps, frames, and more. My mentor, Lonnie McCray, not only guided me along the way but also challenged me in some areas that I thought I was weak in. But by the end of the summer, it showed in my work that I mastered these areas. By adding onto what I already knew, I learned very quickly how to create very powerful web pages. I also learned basic Java, JavaScript, and VRML (Virtual Reality Modeling Language). I used all of these languages in building successful web pages which, in turn, led to a successful summer.

Introduction

This summer I worked for Wright Laboratory's Avionics Directorate. My main purpose was to create Hyper Text Markup Language (HTML) documents or web pages to be posted on the World Wide Web. The importance of making these web pages is providing massive information in just seconds to the world. Not only do Web pages get the information to users worldwide, but they also let the user interact through sending E-mail, making purchases over the Internet and downloading programs onto the user's computer. Working with my mentor, we put our creative ideas together and focused on our goal. The results were three powerful web pages. Out of the three web pages, two are to be posted later this summer.

Discussion of Problem

Creating a web page is simply a matter of compiling HTML codes which tell the written text information and the graphic information how and when to present itself on the page. One of the problems I faced was having to learn other types of programming languages. In order to learn these other types of languages, I went to examples and books to study the code. The easier languages to learn are Java or JavaScript, but the more complex languages are Virtual Reality Modeling Language (VRML). I did some of my programming in VRML for its interactive three-dimensional effect. For example, here is a very easy and basic VRML code to produce a virtual reality cone.

Example 1

```
#VRML V1.0 ascii

Cone {
}
```

The more you learn VRML, the more you realize that there are many more complex codes than the example just given. For example, Example 2 (below) is only the first page of six pages and the six pages is only the first part of several other parts to produce a virtual reality hallway. I have learned that whenever you write any program, you have to create every bit of detail from the stone floor to the chandelier hanging from the ceiling.

Example 2

```
#VRML V1.0 ascii
  Switch {
      whichChild -1
      DEF wall1_base Separator {
          Material {
              diffuseColor 0.3 0.3 0.3
          }
          WWWInline {
              name "hwall2.wrl"
          }
  }
  DEF wall1_wainscot Separator {
      # trim at top of wainscot
      Separator {
          Translocation {
              translation 0.0 3.2 0.0
          }
          Material {
              diffuseColor 0.4 0.3 0.2
          }
          Coordinate3 {
              point [
                  0.0 0.3 0.0,
                  0.0 0.0 0.0,
                  21.0 0.0 0.0,
                  21.0 0.3 0.0,
              ]
          }
          IndexedFaceSet {
              coordIndex [ 0, 1, 2, 3 ]
          }
  }
```

In order to view the VRML programs you create, you need a VRML browser. The browser allows you to scan, not only the web pages you create, but every other VRML web page as well. An add-on feature for your browser which is available for free on the Internet are plugins such as Cosmo Player, Black Sun Passport, and Cyber Passage. Plugins are designed to maximize VRML program usefulness.

Methodology

The work that I have done has been very productive overall. When we started, we were not only going to make web pages for the government, but also work on a data base and computer programming. We did not have a sufficient number of weeks to start working on the data base and computer programming. So, we gave the web pages our total effort. The results were three acceptable pages ready for the net. The two best were chosen for publication.

My mentor and I thought up the best ideas to improve the existing Avionics Directorate web page I started gathering programs off the Internet that already had special features to speed up my programming progress. We worked with frames (splits the pages up) and tables (to better position the objects of the page in boxes), mouse over effects (generates an effect when the mouse is moved over the object), image maps (an image which is broken down into links to other pages) and different types of forms (buttons, search bars, text areas), GIF animation (animation that shows one image at a time), JPG, GIF graphics (names of the types of images) and more. We made these improvements on almost every page.

I started off building a main page that included a title page with several different links. This page involved frames, tables and image maps. It had a top frame for a home and e-mail reference, a side frame with the location of the pages with the information on them. The main frame showed the information and had the top and side frame constantly around it. This page was very good, but it didn't have the full effect we could have given it to attract viewers to the Avionics Directorate page.

However, we set the Avionics Directorate web page back for a little while because the National Aeronautics Electronic Conference (NAECON) briefings were coming up and needed to be quickly posted on the web to get the information out. My mentor told me that I could make this single page however I wanted, but to keep it simple. It only took me about a day to get it done and my mentor was satisfied with it. I used tables, a GIF animation, and links to bring this page to life. I also discovered that browsers automatically download executable (EXE) files, and that came as some help to me. This page is to be posted.

With the NAECON page completed, the Avionics Directorate home page needed something more than the ordinary, so my mentor and I decided to change the whole look of the page that I made my first couple weeks. We used one side frame with no border, tables with no border, a mouse over effect in the side bar, a mouse over effect in the main page involving GIF animation, an image map for the E-mail, GIF animation, Java, JPG, and GIF graphics. In the side bar, we used three main categories: Home (a link back to the main page), Index (a listing of all the topics of the site which were clickable links), Front Office (gave biographies on the director and deputy director). Every time you click to see another directorate, it splits into two frames. A very thin tool bar with an image map appears at the top of the screen leading you back to the main page, e-mail, the Index page, or the Front Office. We also used a program called Webtristy to help use make 3D objects and images. My mentor and I are both satisfied with this web page.

Results

Three web pages were made. Two main pages were made consisting of other related pages, the Avionics Directorate page and the NAECON briefings page. The Avionics Directorate page has several different links; the NAECON page has downloading capabilities. In designing these pages, I learned new languages (Java, JavaScript, VRML). I have also got a taste of the professional world of computer engineering.

Conclusion

I have been in a friendly environment since day one and have learned more then I thought possible in one summer. I am hoping to return next summer to increase my knowledge. This program has given me a look at what the real world is like and has opened up many possibilities for my future plans. In the future, I am planning on taking program classes not only to benefit myself but to hopefully came back and benefit my job as well. I am also going to be looking into the possibility of studying electrical engineering in later years. This program not only showed what I could do for it, but what it did for me as well.

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Books

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Schengili-Roberts, Keith. The Advanced HTML Companion. AP Professional: New York, 1997.

Computer Programs

Paint Shop Pro 3

WebImage

Mapper 32

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Graphic Workshop 95

Netscape Navigator 3.0

Netscape Navigator 4.0

GIF Animation

Impact 3d

Font F/X

WinZip 95

WEB INTERFACE DEVELOPMENT

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Abstract

The World Wide Web today is a vast information resource with enormous potential to help us do our work better. Finding and using needed information from the web however can be problematical. The Avionics Directorate of Wright Laboratory has a great deal of information that it would like to share with not only the public but also the research and development community as well as the user communities. The key to effectively using the World Wide Web to perform this function is organizing, managing and presenting the huge amount of information in a easy to find, easy to use format. The benefits of sharing information include reducing the amount of repeated work done by geographically separated organizations as well as greatly improving the involvement of a diverse community in the development of a product. This improves the chances that the product will be what the end user needs and not what the developer thinks the end user needs.

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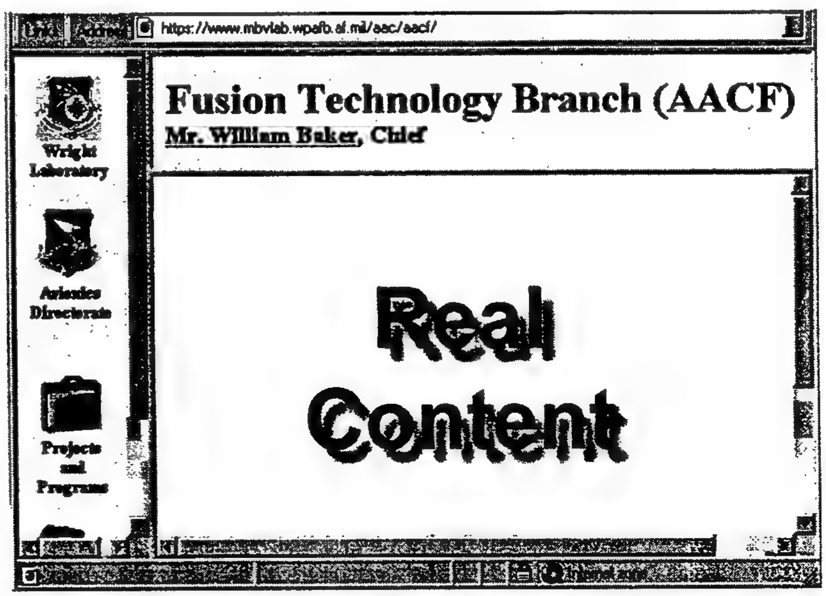
Introduction

The Combat Information division (AAC) at Wright Patterson Air Force Base in Dayton, Ohio, is divided into several branches. Each of these branches have large amounts of information necessary to the division and Avionics directorate level operations. Some of this information is intended for public distribution and some is specifically for Department of Defense personnel only. A method was needed to present both kinds information from the same interface. Using these same ideas we wanted to correct other presentation problems that were common among the old web site pages. In this paper we will go step by step through the different aspects of reengineering the web pages with these problems in mind.

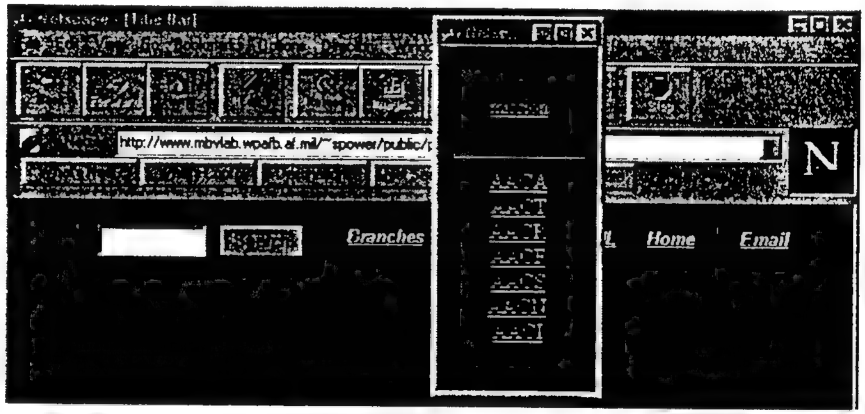
Methodology

Before we could get started on building the new interface we had to look at the problems with the old pages. On top of investigating problems we also wanted to add some new functionality to the pages. Each of the branches under AAC had their own unique interface and presented their information differently. In each of the different sites there were common problems such as useable screen space to display real content as opposed to navigational aids. The previous method of presenting information may have involved a sidebar (a borderless frame on the left side of the page containing various links) or a laundry list of links. These methods involved some searching and scrolling.



Although that gets the job done, complex looking pages can be a distraction and confusing to a user. The division wanted a way to crunch a lot of information into a small area without taking up a lot of view space. The second part of the effort was to develop something that everybody liked so that it could be used as a common thread throughout the division. We began brain storming on what we had so far. At a few good commercial sites, we noticed the use of a top navigation bar. Simply enough, it was a bar of information at the top of the page. And because the top bar was a frame it stayed on top of the page all the time, no matter how long the page in the bottom frame was. It appeared that there was about 50% more viewable space for content, with a top bar than with a side bar. Granted, the space of the bar depended on its contents, but we felt that text, textfields, and input buttons wouldn't take up a lot of space. So we thought we would give the top bar a try.

Our first approach to "cramming" information into the top bar were popup navigation windows. A popup window is actually a web browser without any buttons or toolbars. The basic concept is to let the user ***mouse over*** different buttons. This is done by moving the screen cursor on top of a predetermined portion of the screen. When this is done, the user gets a popup window containing links relating to the area they moved over. The popup windows were created simply enough using javascript. Using the *OnMouse* command, we told our script we wanted a popup window to appear when a mouse moved over a designated area. The script seemed to be running fine. The popup windows occasionally caused errors in Microsoft Internet Explorer 3.0, but that was all.



This is an example of the javascript we used to create the popup windows. Note that we defined the layout of the windows with HTML tags used inside the script.

```
<script language="javascript">
function pop1(label, msg)
{
var s1 = "<title>Branches</title>" +
"<body bgcolor='#000000' link='ffffff' vlink='ffffff'>"
var s2 = "<font color='FF0000'><b><center>"+label+"<br></b></font>" +
"<font color='ffffff'><a href='http://www.aa.wpafb.af.mil/aanew/aacfo.html'
target='bottom'>mission<p></a><hr>"
var s3 ="<a href='https://www.mbvlab.wpafb.af.mil/aac/aaca/WLAACA/index.html' target='bottom'
onClick='self.close()'>AACA<br>"
var s4 ="<a href='https://www.mbvlab.wpafb.af.mil/aac/aact/' target='bottom'
onClick='self.close()'>AACT<br></a>"
var s5 ="<a href='https://www.mbvlab.wpafb.af.mil/aac/aacr/' target='bottom'
onClick='self.close()'>AACR<br></a>"
var s6 ="<a href='https://www.mbvlab.wpafb.af.mil/aac/aacf/' target='bottom'
onClick='self.close()'>AACF<br></a>"
var s7 ="<a href='https://www.mbvlab.wpafb.af.mil/aac/aacs/' target='bottom'
onClick='self.close()'>AACS<br></a>"
var s8 ="<a href='https://www.mbvlab.wpafb.af.mil/aac/aacn/' target='bottom'
onClick='self.close()'>AACN<br></a>"
var s9 ="<a href='https://www.mbvlab.wpafb.af.mil/aac/aaci/' target='bottom'
onClick='self.close()'>AACI</center>"
Popup = window.open("","popDialog","height=260,width=120,scrollbars=no,resizable=yes")
Popup.document.write(s1+s2+s3+s4+s5+s6+s7+s8+s9)
```

```
Popup.document.close()

}
```

The function of the windows works like this. When the user chose a link from the popup window the selected page loads into the bottom frame of the page. After a user clicks on a link, the popup window then closes itself, using the *self.close()* command. We felt I had found the ideal way to present great deals of information without consuming a lot of space. We broke all the links into three different popups: About our branch, Organization, and Restricted. The, About our branch links are the links that pertain only to the branch or division where the bar is located. This list of branch links might involve such things as projects, papers, future plans, and mission statements. These internal links change for each different page that the bar is on. However, the same bar did not comprehensively change itself as it moved from page to page. Instead, each division and branch made its own version of the tool bar. The Organization list are links that are related to the division and directorate sites, not having to do specifically with that particular branch. These are the links that always stay the same no matter which site the bar is at.

The last area a user moused over would be .Mil Only. This list would contain different things such as points of contact, and a list of staff for that particular site. This list, however, would not be accessible by everyone. It would be domain restricted. In other words, people looking at the pages anywhere else but Department of Defense sites would not be granted access. Next, we added other features onto the bar. We placed a small input field and search button in the bar. Just to have a working model, we pointed the search to AltaVista. Eventually, this would be replaced with Netscape's search engine, which allows consumers to designate the sites that they want the engine to search. Using this search tool each of the branch sites could have their own local search. To finish out the bar, we added a few other hot text buttons. We added an e-mail link so that people who are not associated with the base can still send us e-mail. Also, we incorporated a "home" link. This link would reload the site to its original page. Using tables we were able to align all of the text fields with the search inputs. This gave the appearance of a uniformed tool bar.

At this point, we were ready to get some feedback from the branches. Everyone seemed to like the idea of a navigation tool bar. Some liked it at the top; others didn't. Everyone liked the idea of a search engine. The real issue was the popup windows. Unfortunately, the group did not like the windows. Instead they felt that it would be more intuitive if the information were presented in pull down menus. We began working on the pull down menus immediately. In our first implementation of the menus, we placed a load button next to each pull down. To load a link from the pull down menu, a user would have to choose a link and then hit the go button, to bring up the page. One specific, that we agreed on in the meeting, was that we needed to eliminate the go button from the pull down functionality. With the pull down menus, a search button, a search text field, an e-mail, and a home button, there was not much space left for three go buttons. I needed to either find a script that was a click and go, or I needed to alter a current script. It turned out that I simply modified one of our current scripts. From there, we simply put all the links from the windows into the pull down boxes. So now the three pull down menus were in place and fully functional. With this version of the bar, it did not appear that we were having the same problems with the javascript as with the popup windows.

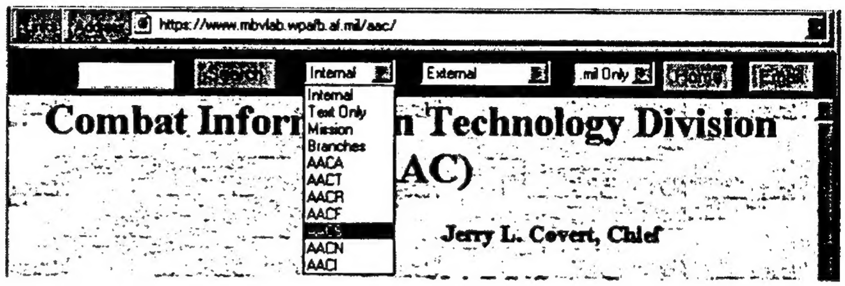
As you can see the amount of javascript used to create the pull down function is much less then the popup window script.

```
<script language="javascript">

function frame1(form)

{

var formindex=form.thislocation.selectedIndex;

window.open(form.thislocation.options[formindex].value,"bottom");

}
```

We did, however, come across a small problem. We discovered that in Netscape 3.0 and earlier versions, the bar would appear to be sinking lower into the page.

This effect would happen as a result of using the history buttons (Back, Forward). At the time, Netscape was just releasing its latest version which did not seem to have this problem. The bar gained enough acceptance the second time around, so that we were able to implement it onto the branch sites.

Despite the small problem, the bar was really at a stage of completion. Moving from left to right, this is what it looked like. First, the name of the branch or division, the standard text color being red. Next in order the search text field followed by the search button. After the button, is the first pull down menu. The division let the branches handle the labeling and organization of the menus. The first pull down menu is, "About Our branch" or something to that effect. Next is the menu containing all the links external to that particular branch. Again these are standard links that never change. The last of the pull down menus is the .Mil Only list. After the three pull down menus comes the home button, followed by the e-mail button. As one can see, we really crammed a lot of options into a thin top frame. At this stage it was just a matter of putting the tool bar into place.



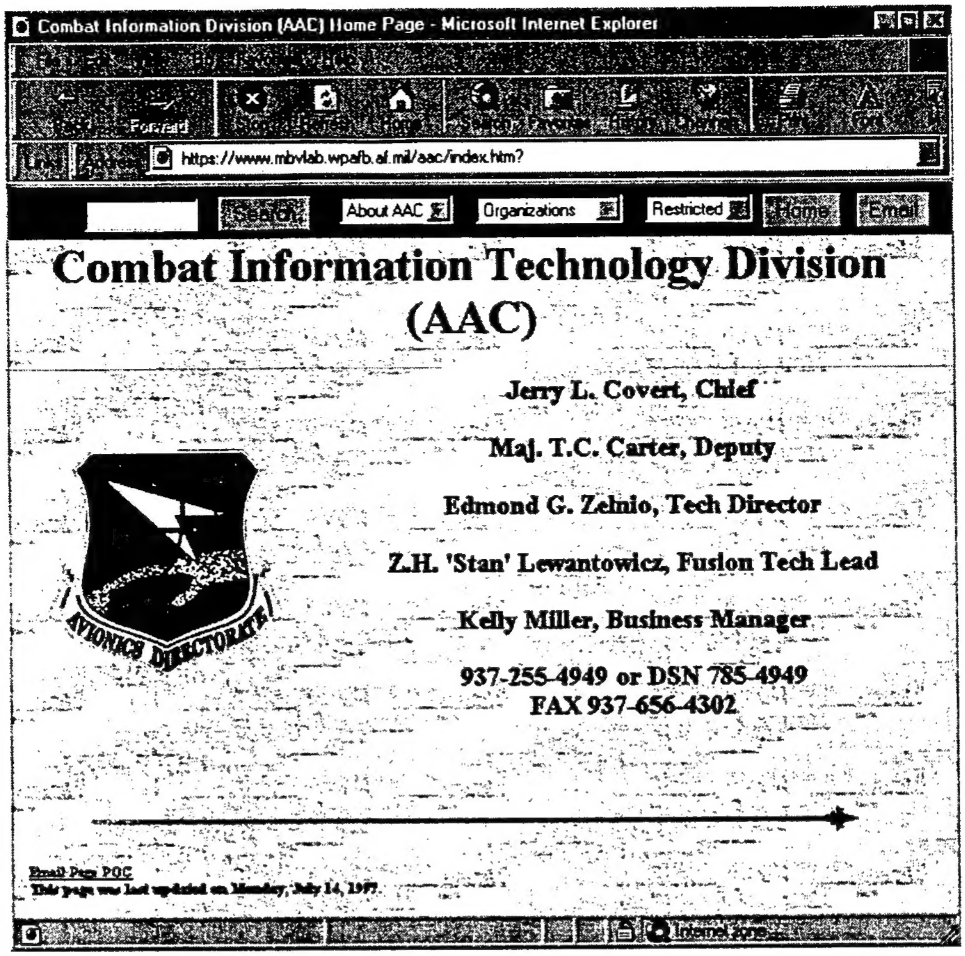
As I had mentioned before, the branches did not have to implement the bar, but it was highly recommended. Overall, four sites, including the AAC division page, requested the bar for implementation. A few branches felt, because the bar would sink in Netscape, it would be insufficient for their needs, and they chose to hold off until Netscape 4.0 came out. Only one of the branches felt they were not going to use the top bar at all.

This process of preparing a bar for a branch was fairly simple. It involved changing only a few things for each branch. The name in the far right corner would be changed to the name of the branch. Next, we labeled the three pull down menus what that branch felt to be descriptive. Of those three menus only two of the list contents had to be changed. Depending on the information each branch wanted to present, the menu consisting of internal items was subject to change. But it could still be broken down

into: Mission, Overview, Projects, and Papers. Anything that pertained to a branch could be placed under the internal menu. Also special material such as a database or specific projects could be placed in the list. As far as the .Mil category, that list usually stayed the same; if anything, more links would be added. Links relating to forms of contact, such as phone numbers of offices or road maps. Under the .Mil category the .Mil Only link would be different. The page it pointed to, would a page containing a list of the people in the branch. For the home button, we just made that reload the URL of the page. The e-mail button actually yields a form that is sent to the web representative for each branch. To set it up properly, it was just a matter of changing the email address of the hidden variable in the HTML.

Conclusion

Overall, we accomplished our goal of a more organized interface. With the top bar we were able to make available different classes of information, and in a way that did not take up a lot of view space. With simple javascript, we were able to create effects that still are not standard methods when it comes to web development. Also with rapid improvements to web browsers such as, Netscape and Explorer. javascript, java, and Active X are becoming very powerful tools. Eventually, I imagine that the whole pull down menu will be done away with and menus more like the start button in Windows95, or something like our original popup menus will be introduced. As far as additions in information, it should be fairly easy to tack on more data. That is just a matter of placing more information in the pull down list. Adding more functions in the top bar may be difficult because the horizontal space is very limited. But when it comes to the web, we find that there is really nothing impossible.


Combat Information Division (AAC) Home Page - Microsoft Internet Explorer
Forward
https://www.mbvlab.wpafb.af.mil/aac/index.htm?
About AAC
Organizations
Restricted
Home
Email
Combat Information Technology Division
(AAC)
Jerry L. Covert, Chief
Maj. T.C. Carter, Deputy
Edmond G. Zelnio, Tech Director
Z.H. 'Stan' Lewantowicz, Fusion Tech Lead
Kelly Miller, Business Manager
937-255-4949 or DSN 785-4949
FAX 937-656-4302
AVIONICS DIRECTORATE
Email Page POC
Internet zone